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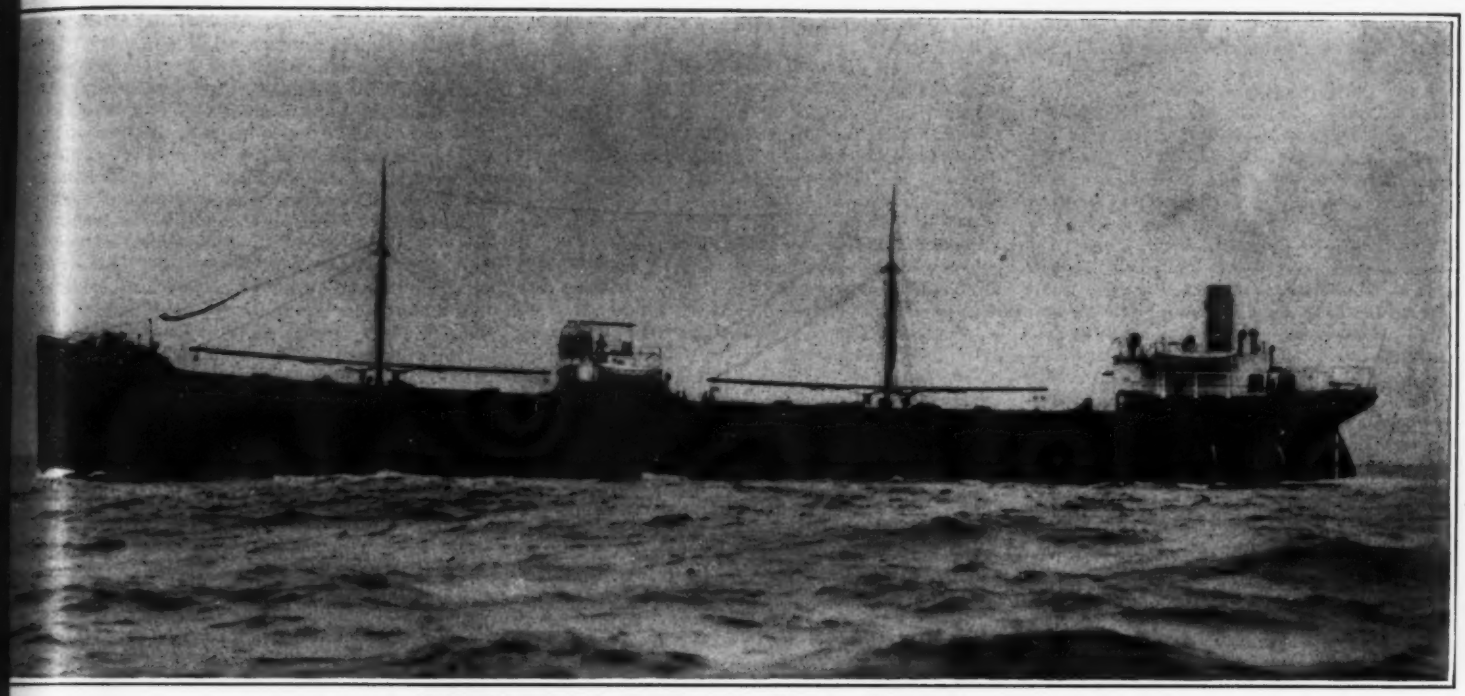
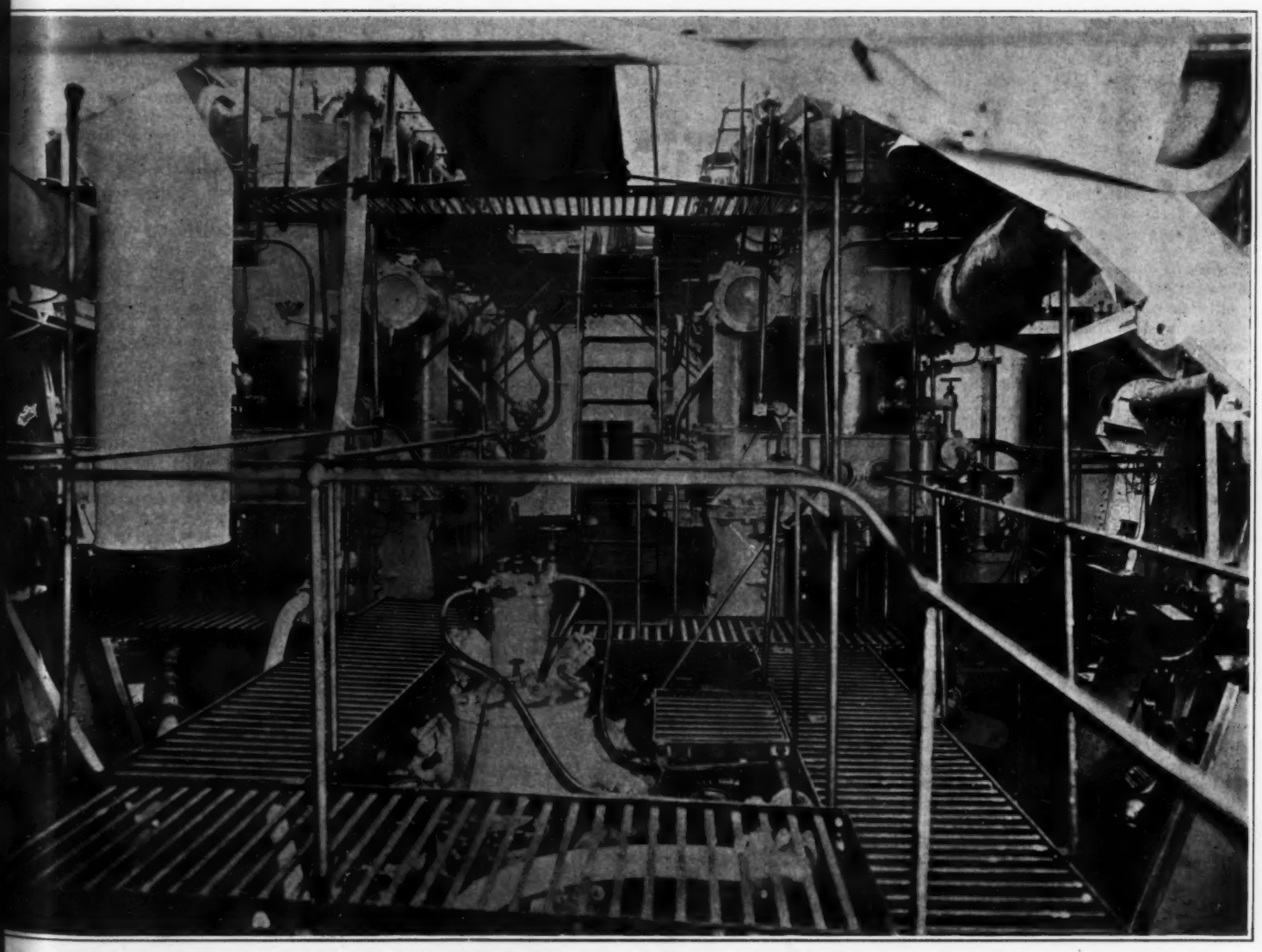


Motor ship "Arum." Powered with twin-screw Diesel engines.



Intermediate platform in engine room of the motor ship "Arum," showing the cylinders on each side in the background, and the head of the auxiliary air compressor in foreground.

MOTOR SHIP "ARUM."—[See page 244.]

The Germplasm as a Stereochemic System—II*

Every Individual is a Chemical Entity That Differs in Characteristic Particulars from Every Other

By Edward Tyson Reichert, University of Pennsylvania

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2023, Page 227, October 10, 1914

C. THE GERMPLASM A STEREOCHEMIC SYSTEM, THAT IS, A PHYSICO-CHEMICAL SYSTEM THAT IS PARTICULARIZED BY THE CHARACTERS OF ITS STEREOISOMERS AND THE ARRANGEMENTS OF ITS COMPONENTS IN THE THREE DIMENSIONS OF SPACE.

If, during the progress of development, there arise the multiple forms of differentiated protoplasm that are represented in the nerve cells, muscles, glands, etc., which exhibit such diversity of form, functions, composition and products, each part being correlated to other parts by the agency of tissue products, it is logical to assume that in the development of the ovaries and testicles these organs have been so specialized as to endow them with the attribute of producing a form of protoplasm that embodies in a germinal state the fundamental peculiar stereoisomerides and the peculiar arrangements or phases of the associated proteins, fats, carbohydrates and other substances which inherently characterize the organism; and, moreover, that owing to the influences of the products of activity of the various tissues upon these organs, such changes in the organism as give rise to acquired characters may, through the actions of modified or new tissue products or foreign substances, affect the operations of these organs and thus alter the germplasm and consequently become manifested in some form in the offspring. The ovule in its incipiency is conceived to be comparable to a complex unequilibrated solution in which changes go on until the attainment of full development, at which time it is equilibrated and remains inactive because of the absence of some disturbing influence, but in which energy-reactions may be initiated physically, mechanically or chemically, and proceed according to definite physico-chemical laws in definite directions to a definite end. As for instance, when a solution of boiled starch and diastase is at a temperature below the minimal of activity and the temperature is raised, causing immediate developmental activation; or when the equilibrated molecules of nitroglycerine are exploded by percussion; or when an equilibrated maltose-dextrose-maltase solution is rendered active by dilution with water.

The *nature of the germplasm* or transmissive material that serves as the bridge of continuity between parents and offspring has been the subject of speculation from time immemorial. Such hypotheses and theories as have been advanced have had reference almost wholly to its physical constitution or ultimate morphological structure. Most of them are micromeric, that is, they hold that the germplasm as made up of infinite number of discrete ultramicroscopic particles which are endowed with both determinate structural and vital attributes. A considerable degree of ingenuity has been displayed in their formulation. Thus, we have the "organic molecules" of Buffon, the "microzymes" of Bèchamp, the "life units" of Spencer, the "plastidules" of Maggi, the "bioplasts" of Altmann, the "stirps" of Galton, the "gemmules" of Darwin, the "biophors" of Weismann, the "pangens" of DeVries, etc., each author attributing to the units certain inherent peculiarities. To the foregoing might be added particularly the conceptions that belong to the chemical category, such as the "chemism" of LeDantec and the "physico-chemical" theory of Delage. Some of these conceptions are so fanciful in the light of modern science as to be unworthy of more than passing consideration, while none of them has led anywhere beyond the field of speculation and reasoning. Even the very recent and extremely interesting and important additions to our knowledge of the histological phenomena of the developing ovum, especially of the chromosomes, have not taken us appreciably nearer the ultimate constitution or mechanism of the germplasm, or even to the nature of the reactions which occur immediately antecedent to and cause the formation of the chromosomes.

A theory to be *ideal* must not only have as its basis well-defined principles that are consistent with facts, but also be capable of substantiation by laboratory investigation. Given as the basis of scientific study a germplasm that has inherently the power of development; that is in the form of a stereochemic system that is peculiar to the organism; that is highly impressionable to stimuli; and that has the marked plasticity that is inherent to organic colloidal matter, we have all the postulates that are needed as a foundation upon which according to the laws of physical chemistry can be built a logical explanation of the essential fundamental elements of the mechanism of heredity.

The *inherent potentiality* that determines the development of the egg along a line of definite sequential processes must be recognized as being common to both animate and inanimate matter and subject to the same laws, so that the phenomena of living and dead matter are inseparably linked and reciprocally explanatory. The typical condition of matter of definite composition is crystalline, and the crystalline form is the result of development that becomes manifested in a separation and orderly and progressive arrangements of components in the three dimensions of space. Having a homogeneous solution of various selected crystalline substances of appropriate chemical composition and constitution, and given conditions attendant to crystallization, the successive stages of crystalline development will proceed along fixed and definitely recognized lines, and the interactions and interaction-relationships between the various substances constituting the physico-chemical mechanism become obvious to a greater or less extent in the peculiarities of form, composition and other properties of the crystals. Having in the germplasm an analogous physico-chemical system, but one which is markedly different especially because of its organic and colloidal character and infinitely greater molecular complexity and sensitivity, the phenomena of development likewise proceed in conformity with the same laws along definite lines, but they are for perfectly manifest reasons more complex and varied, more difficult of analysis, and necessarily in many very important respects quite different. Each step in this orderly development leads not merely to changes of the physico-chemical mechanism by the modification, rearrangement, or splitting off of component parts, but also to alterations which automatically determine the characters of the next succeeding step, and so on to the establishment of physico-chemical equilibrium and the consequent termination of the reactions.

In living matter the chemical processes are dependent to a pre-eminent degree upon enzymes that are formed by the different kinds of protoplasm to serve as implements to carry out operations that are essential to their existence, and such enzymes are modifiable in quantity and quality in accordance with changes in internal and external conditions. The nature of both reactions and products of enzymic action depends upon the constitution and composition of the physico-chemical mechanism of which the enzyme is an integral part. Whether or not at each step of serial reactions a portion of pre-existing enzyme is merely modified or a new enzyme is formed which constitutes an essential part of the particular phase of the reactions is not known, but that one or the other occurs is apparently without question. It has long been established that some of the lower organisms, such as the yeast plant, have the property of modifying the characters of the enzymes produced in relation to varying conditions; recent studies of the animal organism show that the same phenomenon occurs in both tissues and blood; and our knowledge of the processes concerned in the catabolism and anabolism of complex substances, such as starch, is fully in support of such a conception. In other words, as each step of development is reached the alterations which occur in the physico-chemical mechanism absolutely automatically predetermine the characters of the changes of the next succeeding step, and so on to the end. Hence it follows that the peculiarities of any given physico-chemical mechanism predetermine the characters of the phenomena which ensue under given conditions.

An illustration of the probable *modus operandi* of such a mechanism is found in the phenomena of the synthesis and analysis of starch: During the production of starch through the agency of the chloroplast or leucoplast we conceive that there are instituted a predetermined orderly, independent and interdependent series of reactions, the first of which is manifested in an interaction between water and carbon dioxide through the agency of an enzyme in the form of an oxidase to form formaldehyde. During this process there is formed another enzyme, which tentatively may be designated an aldehydase, that reacts with formaldehyde and by polymerization and condensation of six molecules gives rise to a simple sugar, such as dextrose. At the same time, another enzyme appears in the form of maltase, which reacting with the dextrose causes the formation of maltose, during which reaction another enzyme, a dextrinase, is produced which reacts with the maltose to yield dextrin. Going on with this reaction another enzyme which may be designated an amylase appears, which reacting with the dextrin forms soluble starch. During this stage there arises another enzyme, a coagulase, which converts the starch from the soluble to the insoluble form or ordinary starch. At this stage the series of reactions have reached their end because a state of physico-chemical equilibrium has become established, the ultimate purpose of the processes being attained, that is a form of pabulum of extremely high nutritive value and of extremely low molecular pressure, even in soluble form, so that it may entirely and rapidly disappear without disturbance of physico-chemical equilibrium in the starch-bearing cells. The mechanism concerned in starch-formation is, without doubt, paralleled in the synthesis of proteins, fats and other complex organic substances, and it is but a step from the individual serial processes concerned in the formation of each of these substances to associated processes whereby there are formed and combined the various substances that constitute the organic structural components of protoplasm. Moreover, such serial processes are reversible at any stage, and so simple a modification as a change in the per cent of water may, as in the maltose-dextrose-glucase reaction, cause a synthetic change.

In vitro in both synthetic and analytic processes like those which constitute serial steps in the building up and breaking down of starch, protein, fat and other complex organic substances there does not occur in any reaction, as far as known, either a transformation or a production of enzyme such as occurs *in vivo*, hence, when a single enzyme is present it carries out but one step of the reactions, but when, as in the case of diastases as ordinarily prepared, the enzyme is not a single substance or unit body but a composite of a number of enzymes or modifications of a given basic enzyme, serial steps may occur as *in vivo*. Thus, if only a single enzyme be present, formaldehyde may be converted into a monosaccharose, or a monosaccharose into a disaccharose, or a disaccharose into a polysaccharose such as dextrin, or dextrin into a higher form of polysaccharose such as soluble starch, according to the enzyme or modified enzyme and initial substance present; or the reverse of any one of these processes may occur if proper conditions are present, but never do any two successive progressive or regressive steps occur unless through the agency of two different or modified forms of enzymes present.

It will thus be apparent that the first step of synthesis is determined by the character of the initial physico-chemical mechanism and that all subsequent reactions under given conditions are definitely predetermined; in other words, the entire train of reactions depends inherently upon the nature of the initial physico-chemical mechanism of which the enzyme that starts the serial changes is an integral part.

Having a specific stereochemic system, such a system in accordance with the laws of physical-chemistry can exist in either a latent or active state, and that when in an active state the reaction or reactions are always in the direction of the establishment of equilibrium of solution, every reaction or series of reactions being as definitely predetermined as is every reaction familiar to the inorganic chemist. The germplasm in the form in which it is secreted may be regarded as being in the nature of an exceedingly complex stereochemic system which is from its incipiency, or very soon, in a state of physico-chemical unequilibrium, and in which, as a consequence, reactions are set up which are manifested especially in histological developments that ultimately characterize the fully developed ovule, at which time a state of physico-chemical equilibrium is established, as is evident by the arrested developmental activities. This state of physico-chemical equilibrium of the matured ovule may be instantly changed to one leading to serial definitely predetermined reactions by means of an activating substance or condition, such as certain ions or inorganic salts, a spermatozoon, or a needle prick, by initiating the first step of the reactions, the nature of the succeeding reactions being predetermined primarily by the inherent nature of the physico-chemical system and secondarily by the factor that activates it. In other words, from this initial stereochemic system there arises a complex heterogeneous system that ultimately is morphologically expressed in the histology of the matured ovule and from which are formed a composite of correlated, independent, interdependent and differentiated masses which represent different phases of the components of the initial system

Read by title at the meeting of the American Philosophical Society, April 25th, 1914, and in full before the Society of Normal and Pa hological Physiology of the University of Pennsylvania, April 28th, 1914.

which have been modified not only physico-chemically as expressed by changes in physical, mechanical and chemical properties, but also in developmental energies; and from this composite are developed successively other systems.

Owing to the *great impressionability and plasticity* of such an exceedingly complex stereochemic system as the germplasm it follows that the germplasm must be extremely sensitive to changes in internal and external conditions, and that its operations and products may be so materially modified by changes in its molecular arrangements or components as to give rise to variables that are manifested in the transmutability of sex, variations, fluctuations, mutations, deformities, retrogressions, tumor formation, immunities, etc.

Assuming in accordance with our conception that the germplasm is in its incipiency an unequilibrated stereochemic system that is characteristic of the inherent, fundamental stereochemic system of the parent, it follows, as a corollary, that having a highly specialized form of parental structural material with peculiar energy-properties the offspring must of necessity possess essentially the same fundamental characteristics as the parents when normal fecundation has occurred, and that it would be quite as impossible to have any other result than in ordinary chemical reactions under given conditions of experiment. The essential characters of the building material as regards substances, arrangements and energy-properties are definitely fixed within narrow limits of variation.

That the peculiar forms of stereoisomerides or intimately related bodies that are inherent in the parent are conveyed in the germplasm to the offspring, and hence of necessity serve to distinguish a given form of germplasm from that of any other species or genus, and that the stereochemic conception of the nature of the germplasm is capable of laboratory demonstration, are instanced in the results of the investigations of Kossell and his students who found that simple forms of protein, known as protamins, obtained from the spermatozoa of different species of fish are different, each being apparently of a form peculiar to the source. Here is one substance at least that seems to be in specific stereoisomeric forms in the sperm of different species, which obviously must affect the properties of the germplasm, and which when brought in contact with the germplasm of the egg plays its part in determining the phenomena of development. Moreover, by the "precipitin reaction" method Blakeslee and Gortner have found evidence that is consistent with the conclusion that there are not only "species proteins" but also "sex proteins," and this receives support in a number of very recent investigations, especially those of Steinach who found that the corresponding hormones secreted by the ovaries and testicles are different, and that by virtue of these differences the secondary sexual characters, female and male, are determined. Thus, he found in castrated young males, in which transplantation of ovaries had been practised, that the development of masculine peculiarities is inhibited and female traits substituted, so that the individuals tend to assume the female type and become to a striking degree feminized-males, as shown in bodily form, in a development of the mammary glands, in lactation, and in an alteration of psycho-sexual characters. Furthermore, Riddle has found that the ova of the pigeon are dimorphic, one half having an inherent tendency to produce males and the other half females; that the eggs having the male tendency have a higher per cent of water, a smaller size, and a lower per cent of potential energy; and that the "sex-foundation" of the germplasm is transmutable, so that an egg that has inherently the male tendency may become female, and that such females exhibit secondary male sexual characters. The transmutability of the germplasm is comparable in its physico-chemical mechanism to the reversion of the maltose-dextrose-maltase reaction that is caused by a change in concentration of the solution, the dextrose being reverted into isomaltose and not to the antecedent maltose—the male egg is not changed into a female egg but into a modified or feminized-male egg.

In considering the transmissibility of parental substances it is essential to distinguish positively between the stereoisomerides and intimately related bodies that are *inherent* in the parent and those which are *acquired* through infection or otherwise. Thus antibodies that are acquired by the mother may be without influence upon the ovary during the formation of the germplasm and not even become a constituent of the latter. On the other hand, an immunity may be established in the mother that may be conveyed to the offspring, yet curiously enough such an immunity may not be transmitted by the immunized male. In processes of the production of the germplasm the ovary may be as insensitive to the presence of many acquired substances of the blood as are some or all other organs, and there is no more reason in general for expecting the ovary and its product to be affected by such bodies or conditions than there is for the pancreas and the pancreatic juice or any other secretory structure and its product to be affected. Every acquired substance must, in its relations to the ovaries, be governed by the same physico-chemical laws as determine specific selectivities or reactivities in connection with the tissues generally. Hence, any such substance may be reactive in relation to one structure but not to another.

Plasticity as regards sex-determination has been demonstrated in the studies of the development of a male (drone) bee from the unfertilized egg, and of a female from the fertilized egg. Moreover, the developing female bee when fed on ordinary food becomes a common "worker," but when fed on royal food develops into a queen.

The *continuity of the building material* between parent and offspring is seen in its simplest manifestations in reproduction among protozoa by binary fission and budding, by which the part separated from the parent mass is in all essential respects like the parent, having the same fundamental physico-chemical composition and constitution. That in such instances the offspring should be a segmental counterpart of the parent mass seems as obvious as that halves of a cube of sugar should be alike. Similarly, if we have in the ovule and sperm forms of protoplasm which as stereochemic systems are in all fundamental respects counterparts of those from which the parents were developed it follows that the offspring must under normal conditions in accordance with the laws of physical chemistry have the same fundamental parental characteristics, as much so as separated portions of any complex stereochemic system must possess the properties of the initial mass. Moreover, if the stereochemic systems of germplasms of the female and male differ, as must be admitted, it is manifest that the stereochemic system of the egg that has been activated artificially or naturally, as the case may be, must be different, and hence undergo development differences that will be obvious in the offspring. In the first instance, the serial reactions which lead to the formation of the different tissues, etc., are activated by a mere disturbance of physico-chemical equilibrium, which may be due to the conversion of a proenzyme into enzyme or a prosecretin to a secretin, or in other words of an inactive body into an active one. In the second instance, there is not only activation but the extremely important addition of the male stereochemic system which by admixture with the female system constitutes a female-male system. Therefore, in the first place the offspring is developed solely from the female stereochemic system, and in the second place from the combined female and male systems, one or the other of which may be wholly or in part dominant in determining certain peculiarities in the developmental changes. Moreover, owing to the transmutability of stereoisomerides and the multiphase transmutability of stereochemic systems, coupled with the reversibility of metabolic processes which may be due to even the simplest of changes in physico-chemical mechanisms, we have a logical basis for the explanation of the phenomena of sexual dimorphism that is expressed in the so-called male and female ova, and male and female spermatozoa; of primary and secondary hermaphroditism; of paradoxical sex developments where the unfertilized egg develops into either male or female offspring; and of sexual transmutability of the inherently male or female ovule.

It follows upon the basis of our theory that because of the inherent peculiarities of the stereochemic systems of the germplasms and the definitely predetermined nature of the entire series of reactions in accordance with the laws of physical chemistry that "like begets like" because like every other physico-chemical phenomenon, individual or serial, under given conditions, it is *a physico-chemical fatality.*

A French Experiment for Preventing Fogs

THE municipality of Lyons has set aside a certain sum to carry on experiments for preventing local fogs proposed by M. Georges Onofrio, director of the Fourvière Observatory of that city. This well-known meteorologist has devoted much study to the fogs that cover Lyons for many days during the cold season, and has become convinced that these fogs may be lessened, if not entirely obviated. It may be noted, in contradistinction to general fogs that often cover plains of the north of France and the sea fogs that envelop many of the coast towns, that the Lyonnaise fogs are altogether local. Lyons, situated at the confluence of the two navigable rivers, the Rhône and the Saône, has a population of over half a million, and, although containing with its suburbs many manufacturing establishments, can in nowise be considered smoke infested. Frequently in winter the fog rises and filters through the streets, shutting out sunshine and causing discomfort to the inhabitants.

This fog is really an anomaly, because at a comparatively short distance away from the city there may be absolutely no fog. A strong wind will often clean the town of mist and bring a return of clear weather, whereas in cases of a general fog extending over a vast area a wind may be slow in bringing about a return of normal atmospheric conditions. Furthermore, according to the American Consul at Lyons, the fogs in that city do not spread widely, owing to elevated land about the rivers, and are often low-lying fogs. It has been supposed that local fogs were caused by the convergence at this point of winds from the north or from the Alps with those from the south. A chain of shallow lakes, lying upward of twenty miles away from the town, has been likewise blamed, as well as the dust and smoke inseparable from a large city. Careful observation, however, seems to point to the fact that the constant evaporation of the two rivers in and near the city produces a great deal of humidity, which is invisible when the temperature is high, but which readily condenses during cold weather when there is not sufficient wind to drive it away.

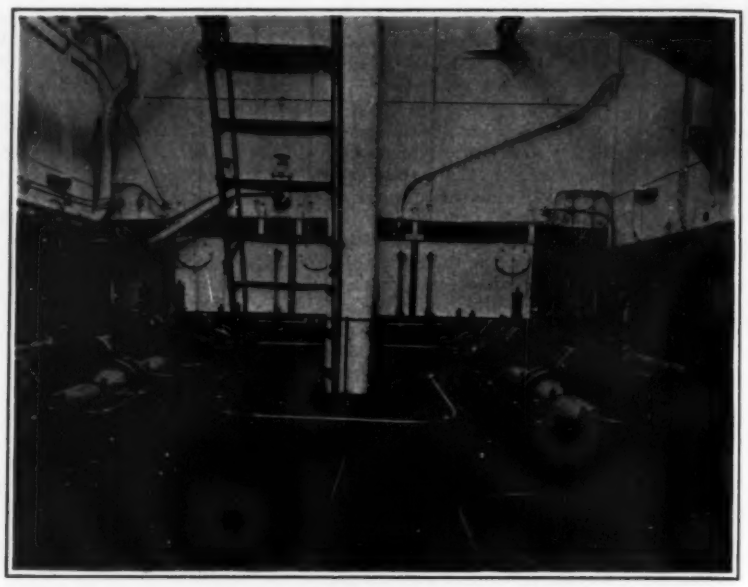
Owing to the heights along the rivers, this fog cannot escape except at one side, toward which a part rolls, thins out, and often disappears. In consequence, much confined, the fog thickens and increases in volume over the rivers, quays, and thoroughfares, and becomes injurious to health and interferes with traffic. At certain times the town seems from some points surmounted by an immense dome of mist, the density and height of which vary according to the temperature and the sunshine. In view of the possibility of doing away with the local fogs, the city authorities have determined to essay a systematic campaign against this plague. Certain measures have already been suggested, such as great blowing-machines from the heights above the city, and also the use of Hertzian waves. The project formulated by M. Onofrio consists in pouring oil on the rivers some distance above the city at a point where the fogs usually collect, so that the surface of the streams will be covered with a thin oil film for a distance sufficient to prevent the rise of vapors within the fog area.

Various facts have been collected from different points, showing the efficacy of the oil coats in reducing the roughness of water, escape of unhealthy odors, and the prevention of rapid evaporation. Experiments have been made by the scientist in question on a small scale with a long vat, at the end of which very hot water was introduced. At the other end there was an opening, so that there was a rapid and regular current. From the entire surface thick steam constantly rose. At about one quarter of the distance from the inlet a dividing partition was let down in the form of a double sieve, holding tow moistened with a small quantity of oil. Following the current, an oily coating extended over the lower three-quarters of the vat, and immediately vapor ceased to rise. It is estimated that a coating of oil of one 1/100,000 millimeter (the millimeter = 0.039 of an inch) in thickness is sufficient to cause the disappearance of the vapor from the boiling water.

This experiment was carried out with water at the temperature of about 185 deg. Fahr., whereas the temperature of the two rivers on which Lyons is situated averages about 59 deg. Fahr.; so it is believed that an exceedingly thin sheet of oil will be still more efficacious when spread over a cold surface, even should it attain the thinness of 1/200,000 millimeter. The thickness proposed for the rivers is 1/150,000 millimeter, which will require about 0.8 of a gallon for about every 460,000 square meters (552,000 square yards). The oil best suited to this work has not yet been determined. Trials are being made with as many as fourteen different oils—animal, vegetable, and mineral—to find one that will come nearest to fulfilling the required conditions. It should be an oil that will spread rapidly and easily over the surface of the water, and at the same time it must be an oil with the strongest possible power of resistance and tenacity. It is possible, however, that some special preparation will have to be devised to meet the conditions.

An oil film that will readily break on the water is of little value. These two qualities are more or less opposed, and it will require some study to find the oil that will spread most easily and still not break. It is thought that an animal or vegetable oil will be found preferable to a mineral oil, though the mineral oils would probably be a good deal cheaper. It is not possible to give the probable cost of keeping the entire city free of fog before an effective oil has been determined upon, although a rough estimate for both rivers puts the expenditure within £6 a day for the cold season. It is hoped, through the exhaustive experiments now beginning, to replace the average sixty-two days of fog with which Lyons is annually troubled by sixty-two days of normal weather. If practice bears out a plausible theory, not only will Lyons receive its full share of sunshine, but other inland cities similarly situated and darkened by fog will be enabled to profit by this simple fog-exterminating method.—*Journal* of the Royal Society of Arts.

Lower operating platform of the engine room of the motor ship "Arum," showing starting mechanism.



Upper platform in engine room of the "Arum," showing heads of cylinders and valve-operating mechanism.

The Motor Ship "Arum"

The Largest Diesel Engined Vessel Yet Built in England

LARGE vessels powered with internal combustion motors of the Diesel type are being built in increasing numbers abroad, and the largest vessel of this kind yet built in England, the "Arum," has recently completed a satisfactory trial and has proceeded to the East to take up her regular work. This ship is 360 feet long over all, 47 feet beam, and 27 feet deep, with a deadweight carrying capacity of 5,000 tons, and was built for commercial work in the Persian Gulf, a feature of her design being a spacious 'tween decks of eight feet, fitting it for the pilgrim traffic or as a military transport.

The special point of interest, however, in this vessel is that she is powered with a pair of Diesel oil engines which drive her through twin screws. These engines are of the Polar type, with modifications and improvements introduced by the builders, which greatly simplify the original design and add to the convenience of starting and maneuvering. They are on the two-cycle principle, and each engine has four cylinders 15.75 inches bore and 33.85 stroke, and at 123 revolutions a minute each engine develops 675 brake horse-power. Each cylinder is provided with its own individual scavenging cylinder, and as this is placed below the main cylinder, this construction makes the engines of unusual height, but they operate very smoothly, with little vibration. All of the valve gear is very simply arranged and is so well inclosed that few moving parts are visible, and many of the complications usually seen in the reversing gear have been avoided. The important point in large engines of this kind of cooling the pistons is accomplished by forcing sea water, through telescopic tubes into the bottom of the piston rod, but in this case it seems to have been impossible to make the numerous connecting glands properly tight. The exhaust is so arranged that it can be either passed up the regular ventilating funnel or under the donkey boiler, which supplies the auxiliaries with steam. Each pair of cylinders is provided with a three-stage air compressor, and lubrication is by gravity.

Cargo is carried in four holds, each fitted with specially large hatchways; and under the cargo holds and in the fore and after peaks there are compartments for either water ballast or fuel oil. In addition to these, fuel tanks have been fitted on deck and in the machinery space, thus providing for an ample supply for long voyages. Suitable arrangements have been made for heating the oil when necessary.

The "Arum" was built by Swan, Hunter & Wigham Richardson, Ltd., who were also the builders of the engines. On its trial trip the vessel made 10½ knots, which was considered satisfactory. These engines are of the "Neptune" type, and are modifications and improvements on the motors introduced by the Aktiebolagt Diesels Motorer Company of Stockholm.

First Aid to the Wounded in War

THAT the eventual healing of a wound is largely a matter of the first treatment it receives is well known. The sooner it is protected from the air the less likely is it that complications due to infection will ensue. Even savages will attempt to close a wound with a bit of cloth, with moss, leaves, or even earth. But such materials of course commonly contain germs of such dangerous diseases as tetanus, septicemia, etc. Consequently all modern armies supply each soldier with a packet containing bandages which can be applied by himself or a comrade pending the arrival of the ambulance and the surgeon. At the December meeting of the French Society of Military Medicine, one of the subjects of discussion was the improvement of the first aid packet hitherto employed, containing a tuft of tow, a gauze compress, a bandage, a piece of waterproof cloth and two safety pins, the whole being chemically purified and impregnated with a 1/3000 solution of bichloride of mercury. The imperfections of this type have long been recognized, and Surgeon-Major Legrand presented to the society a new packet devised by Pharmacist-Major Fétel. This is described and discussed by Dr. Piussan, the Chief Surgeon of the French Army, in the *Revue Scientifique* for August 2nd.

In the first place, the bandages are doubled, since wounds from a firearm are usually double. Another point made is that antisepsis is illusory but *asepsis* is all important. Maj. Fétel's bandage is placed, before any attempt at sterilization, in a first envelope of filter-paper and this point is insisted on as a necessity in the manufacture. Dry heat at 138 deg. Cent. does not destroy the spores of anthrax or of the *bacillus subtilis*, and only a temperature of 120 deg. Cent. in water vapor under a pressure of two atmospheres gives full security. After being dried in a vacuum, the bandage is placed in an impermeable envelope, and for this Maj. Fétel proposes an enameled cloth which will resist a dry heat of 140 deg. Cent. for 30 minutes. This envelope is closed by a narrow band of the same cloth sealed with aseptic collodion (cellulose in acetone). This packet is then placed in a waterproof pocket closing with snaps. Maj. Fétel also proposed to add in an exterior envelope a small vial containing a cubic centimeter of tincture of iodine. This was criticized as being inadequate, though good in theory, and Dr. Piussan adds that the disinfection of wounds can be thoroughly accomplished only by the nurse or surgeon, and the first bandage should be merely for protection.

Dr. Piussan also quotes with approval the report made by Dr. Sallus, Director of the Service of Hygiene of the Sixth Army Corps, who had the happy idea of consulting all the doctors of the corps and combining their ideas. This report appeared in the April number of the *Archives de Médicine Militaire* and contained the following recommendations:

A. The packet should be rectangular, 12 by 10 centimeters, of a weight of 50 grammes, in a triple envelope.

(1) Exterior envelope of strong cloth easy to open by pulling a string.

(2) Interior envelope of parchment paper or enameled cloth in the form of a portfolio, closed and sealed.

(3) Two bandages, each enclosed in filter paper and composed of a wad of tow or absorbent cotton 10 by 10 wrapped in a doubled layer of gauze, folded in half and surmounted by a band 3 meters long by 0.08 centimeters in width, fastened lightly to it at 10 centimeters from its extremity. The other end split for a length of 30 centimeters.

B. The bandage must be aseptic.

C. It is advisable that the special pocket in the soldier's uniform containing the packet should be lined with waterproof cloth.

Dr. Piussan offers the following comment on this proposal:

"We fear that this bandage, so scientifically prepared, would prove a poor covering for the wounds it is designed to protect; moreover special instruction in its use would be needed. A bandage 3 meters long would not well keep in place a band which was slipping. Undoubtedly a better means to this end would be found in rubber-coated adhesive plaster."

Speaking further of the bandages provided in the ambulance service, Dr. Piussan observes that the method by which they are retained in position is of critical im-

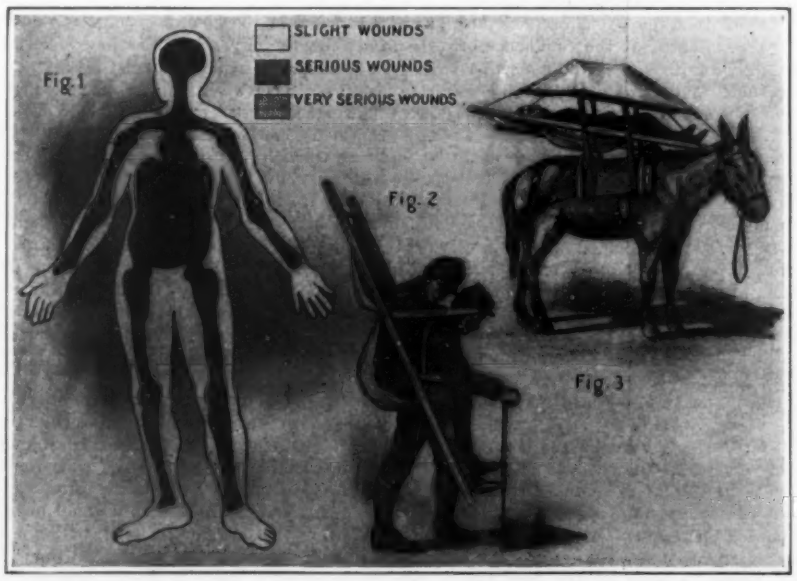


Fig. 1.—The division of wounds according to location shown in the human body. Fig. 2.—Contrivance for transporting wounded man on the back of a hospital orderly. Fig. 3.—Method of carrying the wounded on mule back.

portance, since ordinary bands are extremely liable to become displaced in long transports. He says:

"Dr. Cahier was the first to propose, in 1907, leucoplasts, bands of white rubberized cloth, then manufactured in Germany. These have a very great agglutinative power. Maj. Billet, of Val-de-Grâce, has newly raised the question of adhesive plaster before the French Society of Military Medicine. He has experimented with this idea which is not very recent, since Von Oettingen, in the Russo-Japanese war, made use of a mastic liquid with a base of alcohol and turpentine. This liquid became the '*Mastisol*' so largely employed in the Balkan war. It is very adhesive, and the gauze of the bandages remains fixed fast to the skin around the edges of wounds bathed in it.

"Maj. Billet prefers the adhesive plaster of the leucoplast type to these liquids which form a crust over the wound, and prevent proper drainage. Two rectangles of gauze are applied to the wound and then a slightly larger square of linen. Four bands of leucoplast fasten the edges of the bandage to the skin. A fifth band may be placed crosswise for security. The leucoplast, which is an adhesive band, is very neat, easy to put on, and keeps its position firmly.

"Maj. Reverchon, also of Val-de-Grâce, made use of leucoplasts at the Uskub Hospital. The Servian physicians are in the habit of using them, and Maj. Reverchon is a warm advocate of their use. Different types of leucoplasts are manufactured in France. In 1912, Dr. Filiâtre invented a transparent bandage which merits mention for its originality. It is composed of a rectangle of a special substance called callophane, which is flexible and transparent and is sterilized in the '*Autoclave.*' This is placed on the wound and fastened to the skin at its edges by a band of rubberized adhesive plaster treated with oxide of zinc (leucoplast)."

Dr. Piussan considers this "occlusive bandage" as quite perfect for use in operative wounds, which are clean-cut and aseptic, but not adapted for wounds received in battle, which are to be considered as infected *à priori*. However, the facility of observation will cause it to be retained in certain cases. He advises, however, the adoption of the leucoplast as soon as possible, saying that in the last war it was only too common to see bandages which had slipped, leaving the wound unprotected.

Projectile Photography

Easily Arranged Apparatus for Studying the Flight of Bullets

By Norman Barden

NEARLY all of the fascinating work of photographing projectiles in flight has been done in large laboratories, and those interested in this subject have felt that they had not the required apparatus for such experiments. Now the purpose of this article is to set aside these ideas and to give a clear idea of the whole operation. It may well be said that any student attending a school or college possessing a physics laboratory can succeed in obtaining good negatives of projectiles in flight. As a rule the most serious drawback is the lack of an induction machine, but it is quite possible to use an induction coil in its stead. In the following lines a description and explanation of the complete operation as carried out by the writer in the physics laboratories of the East High School of Minneapolis, Minn., will be given.

The apparatus used in this method of photographing projectiles in flight consisted of an induction machine, a battery of Leyden jars, a spark gap, large condensing lens and a camera. A view of the complete apparatus arranged in a working condition is shown herewith. At the extreme right will be seen the gun clamped rigidly to the table. Placed on the table to the left and back of the gun is the induction machine. Just to the left of the static electric machine is the battery of Leyden jars. Then further to the left is the spark gap, directly in front of which are the condensing lens

Arrangement of the apparatus for photographing a bullet in flight.

and camera respectively. The framework which shows near the Leyden jars is a device for holding two wires by means of which the spark is caused to jump at the spark gap by the bringing of the two wires referred to in contact with one another. The whole operation is carried on in a perfectly dark room save for a dim ruby light. The arrangement of the apparatus is clearly shown in the accompanying diagram.

The arrangement of the apparatus is as follows: The gun is first clamped tightly in a rigid position. Then a target for stopping the bullet is put in position. A target can be made either of blocks of wood or by tying several thick magazines together. Before arranging the rest of the apparatus the path of the bullet must be found. This is done by placing two pieces of cardboard in vertical positions in the apparent path of the bullet. Put one about a foot in front of the muzzle of the gun and the other a foot to the far side of the point where the camera is to be placed. A shot is now fired, puncturing each cardboard. Now by sighting through one hole in the cardboard to the hole in the other, the path of the bullet may be located to a nicety. The next piece of apparatus to be set up is the framework for holding the contact wires or strips in the path of the bullet. The contact wires are placed vertically and must be exactly in the path of the bullet. For the contact wires or strips No. 36 copper wire or leaf copper wire will serve the purpose very well. Having put the framework in the proper position proceed to place the spark gap and the condensing lens and camera in their positions. There can be given no definite measurements for the placing of the last named pieces of apparatus, as different experimenters will probably have different kinds of instruments. However, it is best to place the condensing lens, which should be five or six inches in diameter, about two inches from the path of the bullet.

The bullet emerging from the muzzle. Note the smoke preceding the bullet.

Set it on the side on which the camera is to be located. A condensing lens having a focal length of about six inches will be found to be very well suited for the purpose. Now put the spark gap at such a distance from the lens that the pencil of rays converging from the lens will be brought to a focus at about eighteen inches from the path of the bullet. Then place the camera so that its lens is at the focus of the pencil of rays just referred to. The camera should be focussed on the path of the bullet in order to get a sharp image of the projectile. The optical axis of the camera ought to be perpendicular to the path of the bullet, and the spark gap placed on this axis; also the axis of the condensing lens should coincide with that of the camera. For a clear idea of the arrangement of these pieces of apparatus consult the diagram. Set the Leyden jars and the induction machine in any convenient position. By following the arrangement in the diagram a great deal of unnecessary wiring and a large amount of electrical leakage which is at times very troublesome will be avoided. Connect the machine with the Leyden jars and the jars in series with the spark gap and the second break, thereby making two breaks in the circuit. For the connecting wires annunciator wire may be used; but it should run from one connection straight to the other. Wherever the wires are to be supported they must be highly insulated. Pieces of glass tubing are very convenient to use. Also wherever a wire might

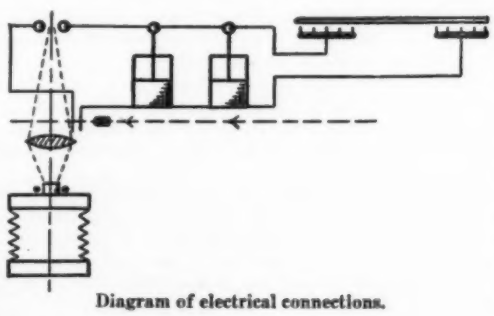
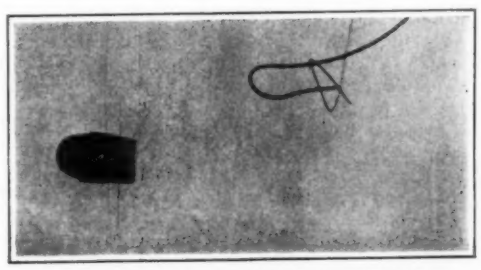


Diagram of electrical connections.

touch anything which might give way to leakage or a short circuit, insulate it with glass tubing or mica. Having put the apparatus in a working condition proceed to try out the experiment.

First of all see that the contact wires are placed exactly in the path of the bullet, and that they are about a quarter of an inch apart. Bend one wire so that the other will surely come into contact with it. Adjust the spark gap so that the terminals are about a quarter of an inch apart. Now operate the machine until the current jumps through both breaks. Do this several times and look for defects in the wiring. On finding everything all right, stop the machine and fully discharge the Leyden jars. Now find out how many turns of the induction machine handle will charge the jars so that they will discharge through both breaks. Do this several times, discharging the jars between each trial, and find the average number of turns. Now try it again, but this time give it four less turns and then push the contact wires together with a glass rod or other good insulator. If the spark is produced at the spark gap when the contact wires are brought within a sixteenth of an inch of each other, the current number of turns has been found. Now load the gun and cock it ready for firing, turn the handle of the static machine the correct number of turns and at the last turn fire the gun. At the same time watch the spark gap to see if the spark was produced or not. After having put all the apparatus in a working condition try a plate.

Nothing has been said heretofore regarding the kind or size of plates or the kind of camera to be used. For the camera one with a lens of large aperture is preferable to one of small aperture. However, the lens of almost any camera may be used if the pencil of rays coming from the condensing lens is focused ex-



The bullet in flight; muzzle velocity, 903 feet per second.

actly upon the center of the camera lens. For the plates, fast ones are best to use, and the faster the plate the better the picture. The writer used Lumiere Sigma plates with good results. The plates should be large enough to show about four of five inches of the path of the bullet. By consulting the illustrations it will be seen that the contact wires were placed so that they just showed on one side of the plate, thereby leaving the rest of the plate to catch the projectile.

After exposing the plate develop it immediately or in a short time. Use any reliable developer and use a solution of such strength that developing will not have to be carried on for more than five minutes. Fix the plate in a strong acid hypo solution, and let it fix about twice as long as it takes it to clear. Wash the plate thoroughly and dry it in such a position that the dust will not settle upon it. It will be found convenient to make the dark room in which the experiment is carried on, serve as the photographic dark room. This saves a great deal of time as well as trouble. If the foregoing instructions are followed, the writer feels confident that there will be no great trouble in obtaining good negatives of projectiles in flight. A great deal depends upon the experimenter, and he must depend upon himself to correct some possible defects which might arise from his own methods of wiring and arranging the apparatus. There is still a large amount of knowledge to be gained by this fascinating work,

and it is within reach of a great many who do not realize the possibility of their carrying out this experiment.

In one of the illustrations, at the left is seen the muzzle of the gun and the projectile which has just emerged from it. Around the back part of the projectile are seen the jets of expanding gases. The volume of smoke and gas which precedes the bullet from the barrel is shown very plainly. The white streak is the spark between the contact strips. Many interesting and instructive pictures of this sort are in reach of those who follow the foregoing explanations and instructions.

The writer wishes to say that he is greatly indebted to Prof. J. R. Towne of the Department of Physics at the East High School of Minneapolis, Minn., as it was through his kind permission that the use of the laboratories was obtained for carrying out this interesting experiment.

Climatic Influence of Forests*

Results of the Destruction of Timber on Climate and Soil

By L. A. Fosbery

THE problem—if problem it is—regarding the effect that forest growth may exercise upon climate and rainfall, is one that has not, to any great extent, been brought within the purview of meteorological science; but, although precise data, accumulated within historic times, is wanting in this direction, the deductions, derived from close observation of cause and effect, as supplied by experience gained in other countries, are not wanting to present a strong argument in favor of the contention.

Without venturing to enter upon a disquisition on meteorological phenomena, it may briefly be stated that the greater importance of the question to Australia, than perhaps to any other country, is chiefly due to the geographical position occupied by that portion of the Continent lying between the 20th and 30th degrees of latitude.

These latitudes, common to both hemispheres, embrace the anti-cyclonic zones or high pressure belts encircling the globe; but, unlike other countries that possess the physical features of mountain, river, and forest, which make for cooler air currents and greater humidity, Australia's center has but few modifying influences to protect its central regions from solar action, and to assist in the formation of cyclonic disturbance and regular precipitation of moisture.

The radiation of heat from exposed earth and rock surfaces assists in the formation of the high pressure area which the heart of the Continent especially favors, and which, by its drying influences, extending far into the settled regions, tends to spasmodic and irregular rainfall, and aggravates the intermittent conditions of drought which prevail to a greater or less extent over vast areas of the country.

To what degree such adverse conditions can be ameliorated by human effort is a problem yet to be solved, but the active and persistent endeavor in every civilized country of the world to remedy the wasteful extravagance of the past by the protection of existing forests and afforestation, both for climatic reasons and the supply of human needs, offers an object lesson which the people of Australia have been too slow to follow, or perhaps too idle to heed.

Since the increase of cultivation and the general destruction of timber, many European countries have become perceptibly warmer and dryer within historic times, and premising that the loss of forest vegetation is one of the predisposing causes, the effects have been to increase the radiation of heat from exposed earth surfaces, to assist the rapid evaporation of moisture, and to give rise to heated and drying winds, which assume greater force and violence when unimpeded by forest growth.

These climatic changes have led to the conclusions that denudation of timber in the cultivated districts has proved a leading cause for the increased dryness of the seasons, the prevalence of violent winds, and the disappearance of the soluble constituents of the soil which have become exposed to the melting influences of sweeping and torrential rains. As a result of these deductions the closest attention has been, and is now being, paid in most parts of the civilized world—even in China and Japan—to the establishment and support of systems of forestry.

The United States—a comparatively young country—possesses nearly 400,000,000 acres of land under forest growth (nearly one fourth of its total area), and yet, despite the efforts now being made to reafforest denuded territories, a timber famine is predicted in the near future.

The State Forester of California has advocated a plan to protect water-sheds, under police power, from devastation by private owners that tend to injure the irrigation of lands lying below.

It has been argued by some that eventually wood will be replaced in many of our industries by iron and other substitutes; and this is held to be a substantial reason for the sacrifice of our forests to the advance of settlement; but apart from the consideration that must of necessity be given to the influences which timber has upon climate, retention of soil and water supply, and seeing that 2,000 years of civilization have not produced an efficient substitute, such an argument is fallacious.

ALL INDUSTRIES DEPENDENT UPON THE FORESTS.

The late President, in his address to the American Forest Congress, said: "The great industries of agriculture, transportation, mining, grazing, and, of course, lumbering are each one of them vitally and immediately dependent upon wood, water, or grass from the forest. The manufacturing industries, whether or not wood enters into their finished product, are scarcely, if at all, less dependent upon the forest than those whose connection with it is obvious and direct." In speaking again as to the importance of preserving timber in the vicinity of open country and great plains, the President said: "Wood forms an immensely portentous element in helping the farmer on these plains to battle against his worst enemy—wind."

The widespread effects upon climate and rainfall through general denudation of timber, whether it be for industrial consumption or for the demands of agricultural settlement, need no comment from those who believe in the climatic influence of forests.

Let us turn again to the observations made in other countries on this important subject. In one of the American Consular reports Mr. D. L. Partello, United States Consul for Dusseldorf (Prussia) says: "A great portion of the private forests has been devastated and made into arable land. In consequence of that, the humidity of the earth diminishes, and the land itself becomes more sterile. Besides that, the useful birds, losing their shelter and places for nests, decrease, insects multiply, and consequently the grain fields are seriously damaged thereby."

Edmund Jussen, Consul-General for the United States at Vienna, writes as follows: "The causes of the destruction of forests have been the same in the old world as in the new. The greed of men, the desire of speedy gain without reference to consequences, the want of judgment and knowledge as to cause and effect in the courses of nature, have shorn the forests along the spurs of the Alps and the shores of the Mediterranean with the same merciless energy which has been displayed in the direction along the shores of American rivers and on the slopes of American mountains. A great area of the shore provinces of this empire is now almost an arid desert. The result in a climatic direction has, as a matter of course, been highly disastrous. The same region which had been famous for its mild and temperate climate has become changeable and unreliable. The mountain creeks have become dry, and the whole face of the country has been changed from a rich, fruitful, and salubrious climate to an arid, sterile plain, interspersed with stony and parched hillsides, populated by meager sheep and their equally meager owners."

Having touched upon American forestry conditions and dismal forecasts, let us for a moment contrast the position occupied by our own State of New South Wales with that of the United States. Instead of 400,000,000 acres of forest area in the latter country—or one fourth of the whole territory—we possess but 20,000,000 acres of forest, the bulk of which is confined to the Pacific Coast, or less than one fifth of the total area of the State.

Pastoral needs have denuded vast areas, suitable for settlement, of timber, which, if the results of destruction had been fully realized, would have been left in appreciable quantity for the use of future generations.

Before the country has become populated the timber has disappeared, and is fast disappearing; how necessary, then, is it to preserve intact every acre of existing forest land in the interior, to assist in satisfying the needs of a coming people, and to stay, if possible, the climatic results of denudation which must inevitably follow.

The probable results that destruction of timber may have upon climate and soil are more especially marked in ancient centers of civilization than elsewhere.

Taking Assyria, Egypt, and other neighboring countries as examples, their monumental remains speak of dense population, both centralized as well as rural, whose needs for great periods of time must have been supplied from extremely fertile sources, necessarily—owing to primitive means of transport—from the surrounding districts. This condition of fertility necessitated the presence of forest growth, salubrity of climate, and a humid atmosphere consequent upon the existence of a luxuriant vegetation.

The physical condition of these countries at the present moment offers the strongest presumptive evidence as to the truth of the main contention.

Here, perhaps, a comparison may be drawn between the arid conditions of these timberless regions and other parts of the world, whose latitudes within the tropical zone should naturally intensify the effects of solar heat and corresponding aridity.

The valleys and tributaries of the Amazon, the Congo, and other great streams are favored by climatic conditions of humidity now almost entirely absent in the higher latitudes mentioned. The masses of aqueous vapor evaporated from these waterways, and exhaled from the dense forests which clothe these great areas, too far distant to be swept into the ocean by variable winds, and checked in their course by forest growth, are precipitated, mainly, within their own limits, thus giving to the climate of these regions the humidity and evenness of rainfall so necessary to render them fitted for the habitation of man.

Given the same conditions of human agency which, in the past, has swept away the forests from the ancient centers of population, would not these regions within the torrid zone present the same barren and arid features which we see to-day in many countries of the old world? If the answer is affirmative, the assumption is clear that the presence of forest growth is a dominant factor in the preservation of favorable climatic conditions.

The question has arisen, regarding the effect of general timber-killing on water supply, the effects of timber destruction on high steep lands on the margins of rivers and other watercourses, and the inducements they offer to floods and erosion.

RESULT OF TIMBER-KILLING ON RAINFALL.

Unlike other countries whose perennial streams are largely fed by melting snows from high altitudes, Australia is dependent for its surface supplies on local rainfall. It may be assumed that as humidity of atmosphere is inseparable from sources of evaporation and exhalation such as protected soil and vegetable growth, so, on the other hand, it may be concluded that the devastation of forests and the denudation of timber generally must result in a lessening rainfall and a diminution of surface water supply.

As timber disappears before the march of husbandry, the increased heat radiation from the earth's surface, laid bare by the destruction of its natural covering, acts as a deterrent to the precipitation of local rains; following which the naturally arid condition of the interior of this continent becomes aggravated under the deprivation of a natural supply of atmospheric moisture.

Ocean-borne vapors which penetrate beyond coastal limits under conditions of low barometrical pressure are precipitated upon bare surfaces with undue violence. The gentle absorption of moisture into the soil by seepage through the protecting humus of the forest is absent, and the rapid accumulation of water, thus permitted to flow unchecked, must render the land subject to conditions of sudden and disastrous floodings.

Timber-killing on high, steep lands leads to more disastrous results than can at present be conceived in a young country like Australia. Experience in this direction has not yet been fully gained, but the knowledge imparted by observers in the old world offers to us object-lessons which cannot with common prudence be neglected.

Touching on this point, and speaking of the devastation of forest growth in the western provinces of Hanover, Mr. F. Raine, Consul-General for the United States, says: "In the western provinces, which are rich in mountains, the fertile forest soil, the result of a thousand years of leaf and needle nourishment, has disappeared from the heights of the mountains. The

* Read before the Royal Commission on Forestry, New South Wales.

scorching rays of the sun, wind, and storms, render the ground arid and unproductive. Rain and snow water have carried what little soil remained down into the valleys, and even the latter have not benefited. The crude and sterile soil of the mountain rubble and pebbles have followed, and filled the valleys with mud and fragments. Moisture is no longer returned to the atmosphere, neither by exhalation from forestal plants nor by evaporation from leaves and loose forest soil."

Under forestal growth on elevated lands the rainfall is absorbed gradually into the subsoils, finding its way to the underlying rock surfaces along the roots of growing timber which penetrate to them, to break out again in springs, and to feed gently running streams along the valleys. The timber being destroyed and root-growth decayed, the surface hardens and offers no assistance to percolation. As a consequence the soil becomes channeled and eroded, being finally swept away in muddy torrents to silt up stream and river beds with sand, stone, and débris.

One great feature in Australian landscape scenery is the aspect of its beautifully rounded and gently sloping elevations, for the most part clothed to their summits with native forest growth.

The geological formations of this country are similar in many respects to those of the old world. Its mountain masses are subject to the same erosive action of moisture, wind, and weather as are those of other countries, and it may safely be concluded that in ancient times the now rugged, barren, and unfertile slopes of such mountain ranges as the Alps, the Pyrenees, Apennines, and numberless others were equally clothed, equally rounded, and as fertile in early days as our own hills are to-day.

RESULT OF DENUDATION.

The same results must follow the destruction of forests upon the slopes and summits of our hills bordering our fertile valleys, as experience and observation in other places have shown; and it must be remembered that, once lost, the soil can never be replaced. Under no condition whatever can reforestation take place in these localities, and no remedy can then offer itself for the evil that has resulted from human agency, its improvidence, its ignorance of cause and effect, or its wilful disregard of the courses of nature.

In the Tumut district of New South Wales one case in particular offers a striking example of present-day neglect. A landholder, with a view to increase the grazing capacity of his hilly lands, ringbarked the whole of the timber upon them, and for several years enjoyed the increased pasturage which followed this operation; but, as the timber decayed, the root-growth lost its prehensile grasp, the soil released thereby became loosened, and gradually left the summits, which have become denuded of every vestige of vegetation. This action will inevitably continue till these hillsides are stripped of their covering, and the intervening valleys filled with débris from them.

The forests existing along our river courses should be preserved by every possible means that legislation can provide.

It has been observed that margins of rivers fringed with forest growth enjoy a higher rainfall than the immediate hinterland of plain or cultivated lands. Whether this is due to an attraction which the presence of water may exert on rain-clouds, or to the impediment which timber offers to the swift passage of vapor-laden atmosphere, we are unable to determine; but, no matter what the cause may be, the fact remains, and for this and other reasons existing conditions should, if practicable, be maintained at all costs, and the waterways of the country remain protected along their margins by permanent vegetation. The shifting of channel beds, the silting up of rivers and streams, the filling in of depressions with silt, mud, and débris by the action of rains, are traceable to the denudation of timber along the courses of rivers and on adjacent cultivated areas, often resulting in impeded navigation and destruction of property.

The question has been asked: "To what extent is it practicable to sow or plant, or sow and plant in the very open tracts of country in the central and western divisions of the State, wide belts of timber, trees, and shrubs, approximately rectangularly to the course of prevailing winds?" This is an exceedingly difficult one to reply to in a practical manner.

TREE PLANTING IN OPEN COUNTRY NOT PRACTICABLE.

The semi-arid conditions prevailing over immense areas of these two divisions, the character of the soil, the prevalence of hardened and baked clay surfaces, sparsely covered in places with but a sprinkling of fertile soil, render the planting and sowing of forest plants, with a hope of satisfactory results, extremely problematical; in fact, it may generally be said that such an attempt in the more open country could scarcely bear serious consideration. The enormous cost of planting and sustaining young plant life, the impossibility of irrigation—at least for very many years—and the difficulties attached to the adaptability of plant-life to soil, present insurmountable obstacles to practical endeavor.

An alternative solution of the difficulty is suggested in the encouragement of native and the indigenous plant-life of the locality by natural rather than artificial means. It is a well-established fact that saltbush country, so-called in early days, will recover to a very considerable extent if protected from feeding by stock, especially sheep. Whether this is due to seed lying dormant in the ground or to root-growth still retaining vitality, or to both causes, the fact remains that the myall, saltbush, and many other saline growths will reappear on protected areas in favorable seasons.

In the years 1873-1878, following the wholesale ring-barking of forests over the bulk of our pastoral holdings, the young pine appeared, to reafforest by natural means the regions once occupied by pine forests. An immunity from destruction by bush-fires, owing to the overstocking of the newly-grassed country, resulted in dense growth of this timber appearing over large areas. This growth was unquestionably from dormant seed, but whether or not a further supply still remains, to spring into life within protected limits, experience and trial can only show.

NATURAL AFFORESTATION.

In the more open country, if strips of land from 5 to 10, and even 20, chains in width, and at distances from 4 to 6 miles apart, in parallel lines, were fenced and wire-netted as a protection from stock and rabbits, it is highly probable that the areas so set apart would resume the indigenous plant-growth native to the localities, and become useful as wind-breaks and as a check to the movement of soil, so prejudicial to pasturage and profitable occupation. Large areas in both divisions have become wind-swept owing to the absence of native shrubs, such as the salt and cotton bush, which at one time protected the surface soil, and this has resulted in a serious diminution of grazing capacity and a loss to the pastoral industry.

The denudation of native plant-life is also due to the improvidence of over-stocking, the destruction by rabbits, the trampling and loosening of the soil by stock, the melting influences of rain upon its soluble constituents, and the prevalence of high, dry, and heated winds, which remove the lighter particles in violent dust storms without check or hindrance. It has been observed, however, that as the smallest obstacle offered to the drifting of soil over compact and smooth clay surfaces will have a local effect in arresting the movement, so it may be inferred that barriers or screens erected at suitable intervals, rectangularly to the direction of prevailing winds, may have the general effect desired.

The prevailing westerly and northwesterly winds of summer would permit of north and south lines being adopted as the trend of such barriers. Existing netted fences on surveyed lines could be utilized with convenience, and at much saving of labor and cost. Absolutely straight or unbroken lines would not be imperative. Overlapping lines—although at considerable distances apart, where existing fences were not conveniently placed— would still present a front to the wind with the same general effect as an unbroken line. Thus a series of short, or comparatively short, barriers could be extended in a proper direction for indefinite distances.

In the western districts of Victoria the open plains in the neighborhood of Mount Elephant, Galla, Gallalabad, and Lara are subject to bleak and piercing winds during the winter months, and stock suffer proportionately; but, wise in their generation, many of the pastoralists planted strips of blue gum across the open country rectangularly to the prevailing winds, which have developed during the last thirty years into forest proportions, and now afford both shelter for stock and timber for domestic use.

In the more open country the natural growth could be supplemented by the planting and sowing of saline herbs and shrubs suitable to the climate and soil. The wind-borne soil would make a valuable seed-bed within and against these barriers, and various kinds of saltbush could readily be established. Although the plantations within would be efficiently protected from stock and rabbits by wire-netting, hedges of saltbush will extend their shoots through a fence sufficiently to afford a large amount of valuable food for sheep without injury to the parent stems; and it is reasonable to suppose that, when duly established, these food supplies would permanently and efficiently increase the carrying capacity of this class of country.

EFFECT OF BARRIERS.

The effect of these barriers would be to stay the progress of shifting soils, to break and cool prevailing summer winds, to modify the rigor of winter, and to offer shelter for stock. In addition to this, it might be hoped that the vegetation encouraged within the protected areas would result in a seeding of the land on either side of them.

Within the closer country the natural growth of the locality should be given encouragement to reassert itself through the protection afforded by these barriers or wind-screens; and if necessary the sugar-gum, fir, silky oak, and other quick-growing plants of a hardy nature could be planted where the maintenance of young plant-life would not involve too great an expenditure. In the pine country the young timber should be rigidly preserved and encouraged to grow within the barriers by natural afforestation. All green timber on existing roads should be preserved, especially on those running north and south, and where practicable the barriers might be erected adjoining them, so as to offer additional width to the screens and to assist as fire-breaks.

The steps to be taken in the formulation of necessary detail in connection with such a scheme would not present insurmountable difficulties.

As a work of supreme national importance, the Government would doubtless be prepared to meet the cost of so reasonable an undertaking; but, in such a proposition as presented here, every member of the pastoral and agricultural community should be prepared to join in support of it. It will be seen that if each landholder is made responsible for that portion of the work which touches his own estate he will see that it is faithfully done and properly maintained, both in his own interest and for the national benefit.

Although the Crown Lands Acts provide that the timber on certain classes of holdings shall be preserved to the extent of one sixteenth, the rule is more honored in the breach than the observance.

If a rule was made absolute that the outside boundaries of all holdings taken up under the Crown Lands Acts—to a depth proportionate to their respective areas—should be left in a green state wherever practicable, several beneficial results would accrue. Heat radiation from the cultivated areas would abate, living, and cooling screens would be presented to the heated and drying winds of summer, rapid evaporation would be checked, useful birds would remain, and exhalation from forest growth would, to a certain extent, continue. Timber for domestic use, firewood, and building material, would be available, and the general comfort of settlers upon such lands would be insured. In addition to the advantages above mentioned, these barriers and fringes of green timber would be found to act as efficient fire-breaks, to minimize the danger from widespread conflagration.

DECADENCE OF NATIONS THROUGH DENUDATION OF TIMBER.

As the whole of the inquiry into this vital question is directed to the comfort, well-being, and prosperity of man, and of a nation yet in its infancy, it may not be out of place to refer to a question which does not appear to have been seriously considered by historians: "As to how far the decadence and eradication of the ancient nations of the world are attributable to the denudation of timber?" It is certainly conjectural, but in studying the general laws which govern cause and effect it may be inferred that where, through the improvidence of a people, forests disappear, humidity becomes lost, fertility vanishes, and climatic conditions are so altered as to result in barrenness and absolute poverty of life-sustaining elements, man, deprived of sustenance, disappears with the vegetation he has destroyed. The sandy wastes of Arabia, Assyria, Babylonia, Persia, and Egypt, the once densely populated centers of high civilization, are examples which offer themselves to the thoughtful mind in this particular direction as a warning and a lesson.

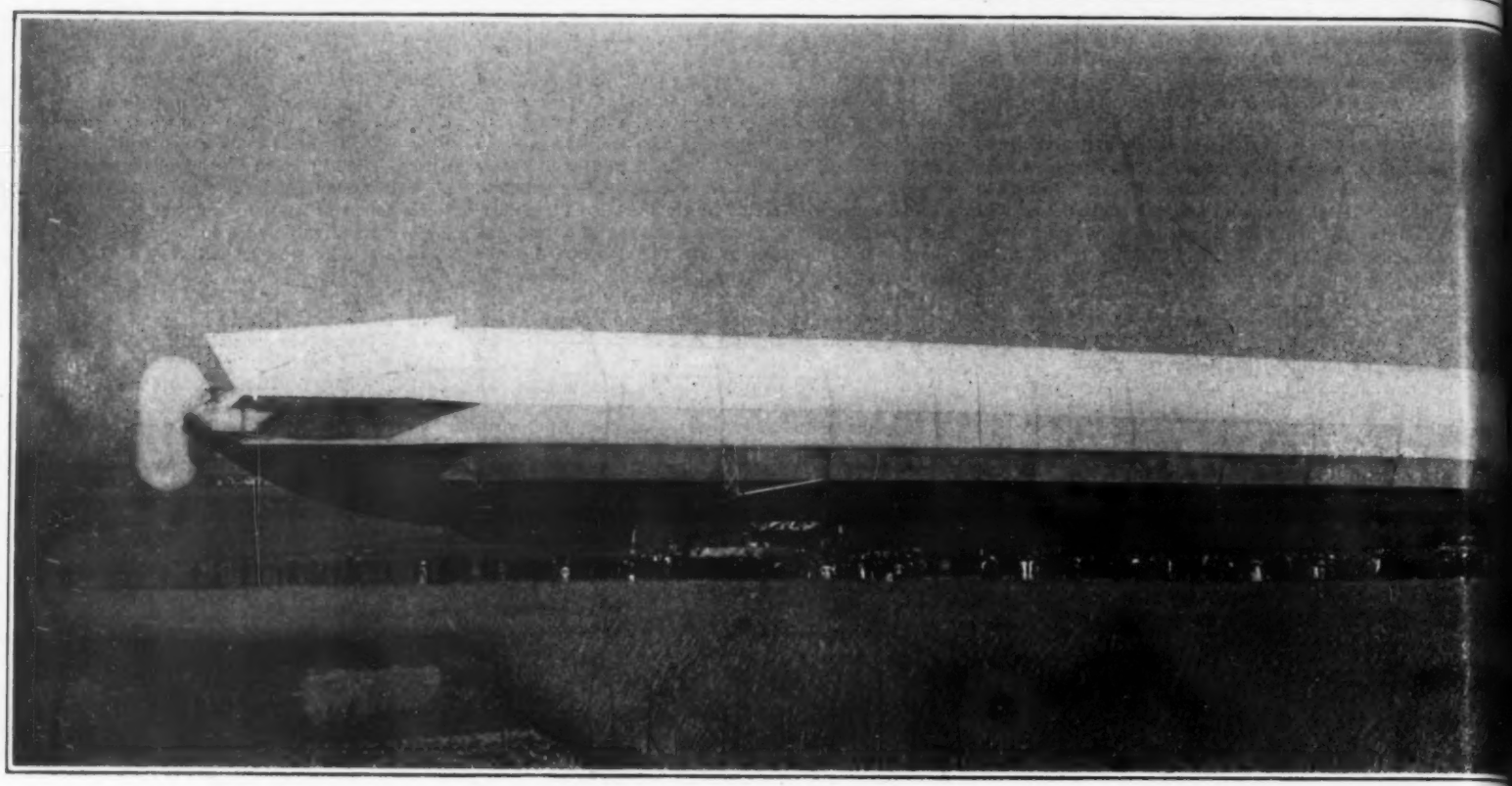
Influence of Chemicals on Germination of Seeds

FARMERS and gardeners sometimes soak seeds in various saline solutions, or fumigate them with certain vapors, in order to preserve the seeds and protect them from insects. This process should not be applied ignorantly, for, while some chemical agents accelerate the germination of seeds, others retard or even prevent it. The neutral salts of the alkali metals produce very remarkable effects on seeds. A ¼ per cent solution of potassium chloride prevents germination, and a 1/10 solution of an alkaline nitrate produces the same result.

This toxic effect, which is probably due to a reaction between the salt and the proteid constituents of the protoplasm, is strongest in the salts of caesium and lithium, and weakest in those of subidium. Roots dipped in the saline solutions are very strongly attacked.

On the other hand germination is accelerated by very small doses of the sulphates of caesium, lithium, and subidium. The strength of the solution should not exceed 1/100 per cent for caesium, 1/20 per cent for lithium, or 1/5 per cent for subidium sulphate.

Carbon bisulphide, potassium bichromate, corrosive sublimate, copper sulphate and aniline, in exceedingly small doses, also accelerate the germination of seeds. —*From La Nature.*



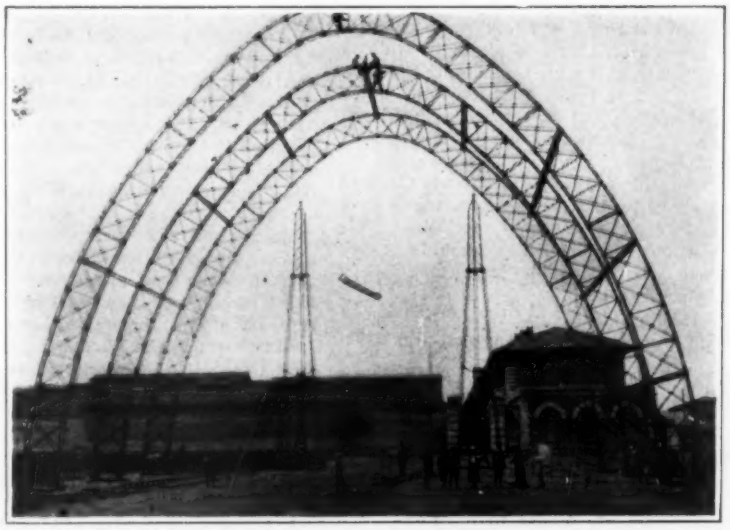
A Zeppelin dirigible coming out of the great h[illegible]ngar—on

New Hangars for Military Uses

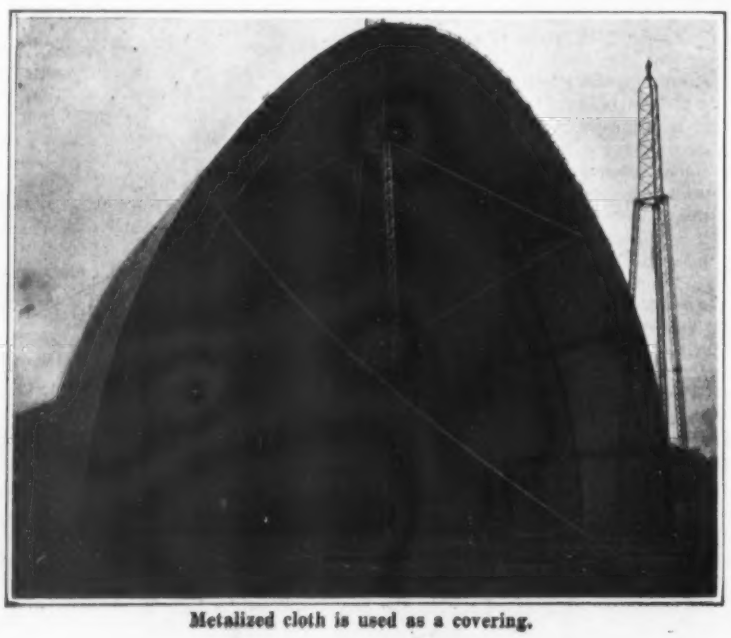
Portable Structures for Use in the Field

THE question of providing suitable hangars for airships has received much attention in military circles in the leading countries of Europe, in order to keep pace with the development of airships for army use. Such hangars may be divided into two general classes, one of these being a balloon shed of the fixed and permanent type which is erected once for all and belongs to certain military aeronautic establishments. Up to the present it is the permanent hangar which has received the greater share of attention on the part of designers and constructors, but not less important is the type of movable shed which is also needed as part of the army material in order to give a suitable shelter for airships when carrying out military operations in various places where they may be at a considerable distance from any of the permanent posts. The question of a portable hangar has also been the object of research on the part of constructors, and we illustrate one of the most recent ideas of the kind which has been brought out in Italy, this being the Bosco and Donadelli system, and it is worthy of note for several reasons. As several of our engravings show, it has been tried in field work by the aeronautic corps of the army.

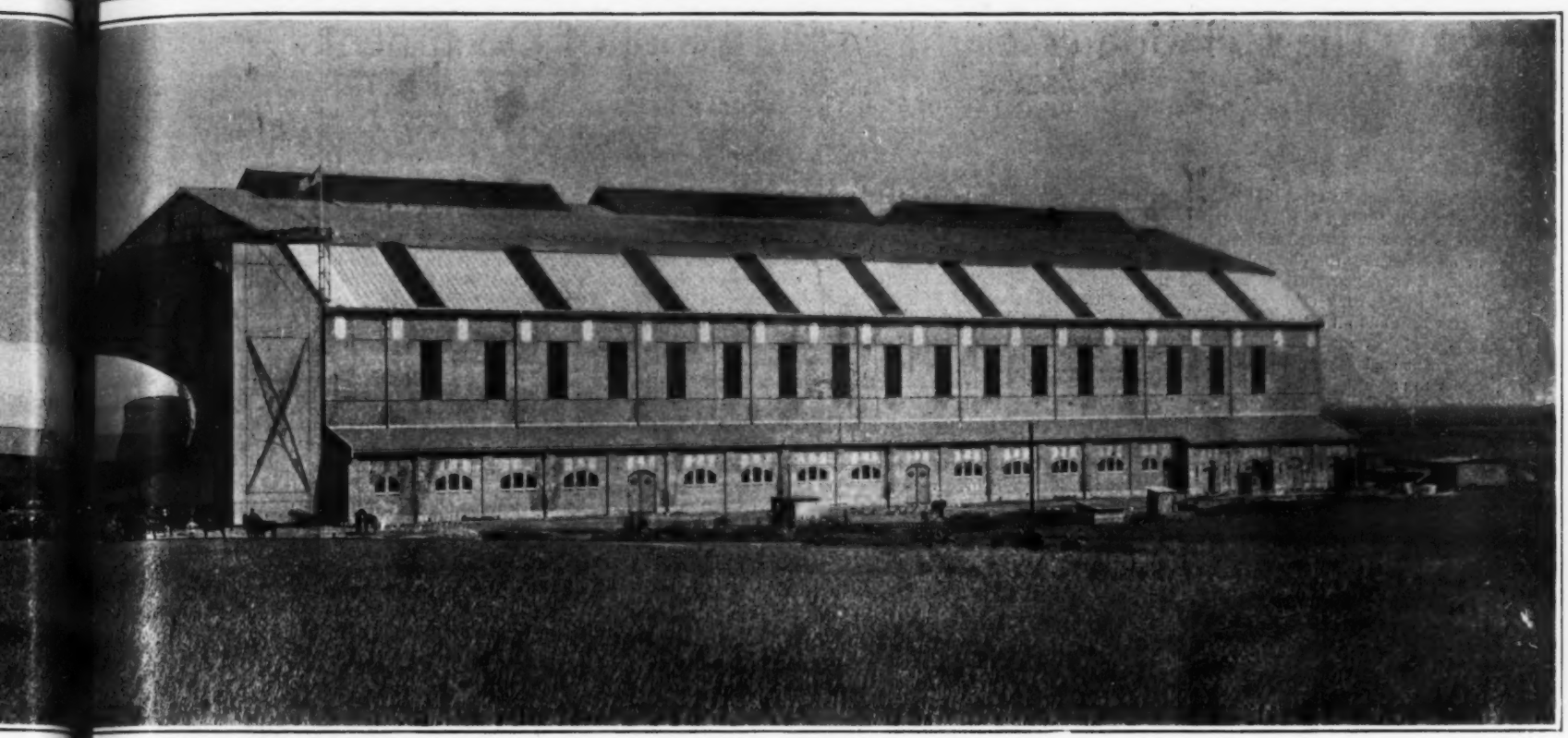
The different sections which make up the arches are locked together by using a hinge clamp which is peculiar to the present system. Toothed projections on one piece fit into recesses on the opposite piece like the two halves of a hinge, so that when placed together, all that is needed is to run a pin through the matched holes in order to couple the two pieces. Each arch is made up of a certain number of sections which are thus joined together, and there are two separate hinge joints used at the meeting point. After locking one joint as we have seen, this forms a hinge so as to bring the other joint in place, and it is then ready to be locked as before by means of a pin, so that the two sections are tightly fixed together by means of the two joints. To dismount the sections, the only operation needed is to withdraw the two locking pins so that the joints readily come apart. In this way the arch is built up while it is lying on the ground, and is then ready to be mounted in an upright position. At the proper points on the ground the base plates are laid which form the foot of the arch. Each plate carries projecting lugs in the shape of a half-hinge. These are made to match with a like part on the arch end so as to make the joint. After running a pin through the hinge while the arch is lying on the ground, the last is raised to the upright position by using ropes and pulleys, and when in place, the second joint between base-plate and arch now matches, and this is fixed by driving in a pin, so that the arch is now fixed to the base-plate very strongly. The second arch is now raised in the same



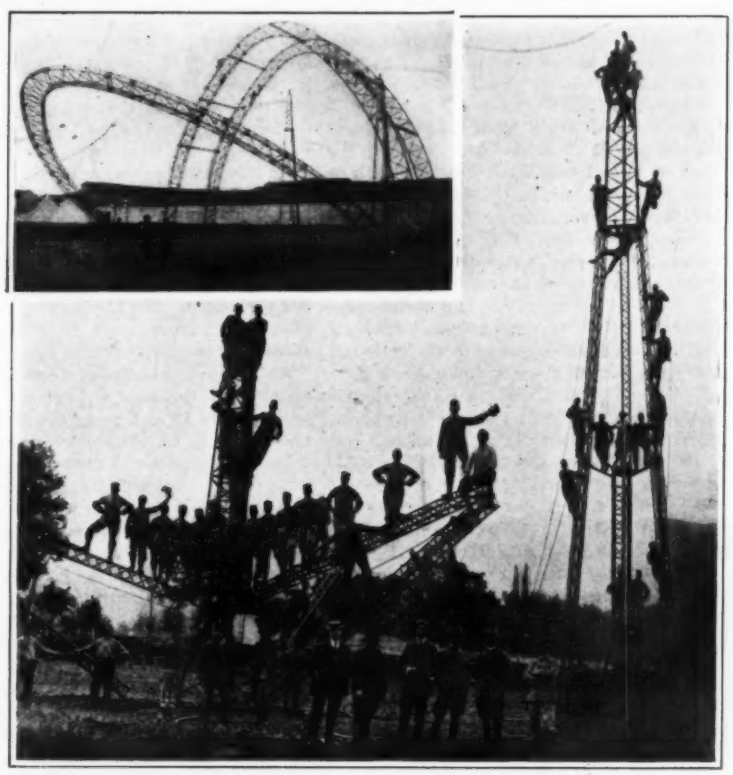
Each arch is built up in sections on the ground and is then raised into position.



Metalized cloth is used as a covering.



he gren gne—one of the largest of its kind in existence.



Arches in the course of erection. The pillars are built up of hinged sections.

way, and the two are bound together by cross brace pieces of structural iron work, as will be noticed, and so on until the right number of arches is erected.

Another point in the assembling of the hangar needs to be considered, this being the erecting of the structural iron poles or towers which are required in order to draw up the arches by means of cables. It has been a problem to set up such towers in the proper way in field work, as they must have a considerable height in order to serve for handling the arches and at the same time must be very strong in view of the great weight of the arch. The Italian constructors make use of the hinge joint principle in a very good way for mounting the towers. In the first place, a short structural iron pole is fixed on the ground upon the base plate so as to form the lower and center part of the tower. It carries a set of pulleys at the top for use in raising the rest of the tower in place. The base plate is triangular, and at each end of the triangle a beam of the tower is fixed by means of a hinge joint. This beam is in reality double, having a hinge placed at the middle upon its height, but both sections of the beam can lie on the ground owing to the hinges. All three beams come together at the outer or top ends and are hinged to a single top pole or cap. The whole can be assembled with the sections lying on the ground with the exception of the top cap, which fits down over the middle post. When the hinge joints are assembled, the whole is drawn to an upright position by ropes and pulleys, and in this position the second joints between the various pieces all come together so as to be locked in place by pins, thus making a three-sided tower with its cap-piece, and the whole construction is very solid.

On dismounting the tower, the men climb to the top and draw out one of the hinge pins at each locking point, leaving one joint which acts as a hinge as before. The tower is then lowered, as a whole, in the same way as it was raised. All these operations can be carried out in a short time. When the first two arches have been raised and bound together, the tower is no longer essential, for the arch structure can now take its place so as to carry the ropes for raising the other arches of the hangar.

A new fabric is used for the covering material, comprising a metallized cloth which has great strength and is also weather-proof. It hangs down at each end of the hangar as a double curtain which can be drawn apart at the sides. The dimensions of the new military hangar of the present standard type are 270 feet length by 100 width and 80 height. A very good speed in mounting is assured, and all can be put together within two days. When transportation by railroad is necessary, the folded metal work, with the covering and all needed parts, can be carried on a train of twenty cars.

An example of recent construction as regards the other class of hangars, that is the permanent balloon sheds, is shown in the type which has been erected at Cologne by the Augsburg-Nürnberg machine firm in order to house the Zeppelin airships. This hangar is noteworthy as being one of the largest of the military balloon sheds yet to be erected. One of the points which occupied the designer's attention was the operating of the large double doors at the end of the hangar. In spite of the great size of these doors, a suitable method of electric motor drive enables them to be opened in four or five minutes. The total length of the present hangar is very nearly 500 feet, its width 170, its height 92. The double doors are 82 feet high, and each door is 24 feet wide.

Power and Balance of Big Aircraft

THAT the large aeroplane of the future will be driven by two engines or more seems certain, not only from the point of view of increased reliability, but from considerations of an engineering character. The difficulty of concentrating the enormous weight of a power plant developing, say, 500 horse-power in a single spot without subjecting the machine's structure to excessive and dangerous stresses must be obvious enough, however desirable this arrangement might be in so far as flying efficiency and behavior of the aeroplane in the air are concerned. For structural reasons, therefore, the most important masses of the machine would have to be distributed, a process which would involve an increase in the lateral moment of inertia, which is not without its disadvantages, for while an aeroplane possessing considerable lateral inertia is not so prone to assume an unstable position as the result of a gust, it would clearly recover its balance, once this had been lost, more slowly and with greater difficulty. In this respect, fortunately, an increase in the size of aeroplanes has beneficial results, for all these large aeroplanes are stable in the most noteworthy manner. This is probably due to the fact that wind gusts are nearly always strictly local and of small extent, so that while a gust striking one wing of an aeroplane of small span might tend to upset it to a dangerous degree, a machine of huge dimensions would only be slightly affected, and would probably sail majestically through gusts and eddies in undisturbed balance.—*Daily Telegraph, London.*

The Relation of Light to the Proof of Documents*

Proper Illumination of Courts Necessary to Insure Justice

By Albert S. Osborn

I CAN think of no association that bears a name which affords such a temptation to the manufacture of figures of speech as an Illuminating Engineering Society. The name at once suggests the dark places that need your assistance. Every department of human activity does indeed need illuminating engineers, and what we all want everywhere and all the time is more light.

Light is an important factor in the proof of documents and light engineers can promote justice by making it easier to prove the facts regarding disputed documents. Anything relating to the subject of illumination that affects the quality of human vision is of vital importance in all forgery investigations. Justice has been defeated many times because court-rooms like cathedrals have been lighted with a dim light somewhat in harmony with some of the hampering old legal precedents. Partly because of poor illumination, judges and jurors in many instances have not been able to see properly, where the case depended chiefly upon visible evidence. This partial blindness in the past has been due in some degree to an ancient legal procedure that threw a twilight gloom around legal investigations, weaving such a network of restrictions about them as made it difficult to prove a physical fact. Strange to say, objections are still made to the use of the microscope, to photographs, and aids of every kind, and these objections, even in these days, are now and then sustained. All these old restrictions have been intensified by poor lighting and improper physical surroundings as well as by individual but unconscious deficiencies in seeing ability, for there is, in fact, a form blindness akin to color blindness.

When the necessity arises for proving a somewhat obscure physical fact by visible evidence, this whole question of human vision, with its defects and limitations, becomes a question of vital interest. In the first place, it is important to realize that seeing ability is not by any means the same with all observers. It is an encouragement to improve our sense of sight to realize that only part of our skill comes by Nature and that much comes from study and experience.

It is also helpful to consider just how it is that we actually see what we think we see. We all know that when we hear sounds we perform a mental operation and from these sounds infer certain things. From arbitrary combinations of sounds, for instance, we get an English word which conveys an idea, or from another combination a German word, and from still another combination we infer that a man is walking or a horse is running. When we see things, however, we are inclined to assume that we are receiving directly in the brain positive information instead of certain sensations which we must mentally interpret just as we have interpreted the sounds.

In much greater degree, therefore, than we are inclined to admit, it is no doubt true that we really see but little more than we are able to compare with some experience or standard that we already have in the brain. The savage does not really see a steam engine, or a watch, or a city, and in some degree we are all in the savage class. The thoroughness of this mental comparison and the final accuracy of sight depends upon two things, the force and clearness of the sensation that reaches the brain and the experience which the brain already possesses. The necessity for seeing clearly, therefore, is that we may interpret accurately.

This whole question of human vision and the aids that perfect and intensify it, is naturally closely related to the question of discovering forgery and the numerous other physical conditions that may point to fraud of various kinds in connection with disputed documents, and is of special importance in connection with the showing and proving of these facts in a court of law, often against prejudice, and usually with untrained men who must be made to see and understand. It is therefore essential that sense impressions of all kinds be clarified and intensified in every way possible, and the arrangement, distribution, and management of light has a most important bearing on the subject.

Under the old legal practice, now happily, but all too slowly, passing away, expert testimony regarding forgery and documents, involving as it does many technical interpretations of visible evidence, was mainly the giving of bare oral opinions on a contested question in courts of law. This practice, much criticised and discredited, still continues in certain cases relating to insanity and some other subjects that the ordinary man, no matter how assisted, is unable to pass upon intelligently. A new practice, however, has developed in most jurisdictions in connection with proof of physical facts relating to documents, by which referee, judge, and jury are actually shown the basis for whatever opinion is given, so that with the assistance of reason-giving testimony, now admitted in almost all courts, and with the aid of instruments, and enlarged, properly grouped photographic illustrations, they can finally reach their own conclusions regarding the disputed fact. Testimony is not simply oral, as in the past, but visible as well.

With the new and enlightened procedure and a court-room where seeing and hearing is possible, numerous surprising verdicts in cases of this class have been rendered. Three recent New York cases are conspicuous examples. In the first, four alleged eye-witnesses, two of them of irreproachable character, testified to the execution of a will and a jury decided it was not genuine; in the second, six witnesses testified that they saw a certain contract signed and a jury decided the document was a forgery; and in the third, a jury convicted a distinguished member of the bar of forgery of only two short words in typewriting that, by comparison, were shown to be written on his own typewriter.

It will readily appear that this change of practice regarding visible evidence makes necessary such an illumination of court-rooms or trial chambers as makes it possible to see with the utmost distinctness. To the end therefore that visible evidence in cases of this class, and in all kinds of cases, may be presented with the utmost clearness and force, it is highly important that an illuminating engineer be consulted in regard to the arrangement and lighting of every court-room.

Another reason why court-rooms should be properly arranged and lighted is to enable judge and jury to see witnesses with the utmost distinctness as testimony is being given as well as to hear them. That this result may be attained, it is necessary that witness-box, jury-box, and judge's bench be arranged in proper relations to each other and near together. Fortunately, there is in all of us a kind of instinct, enforced by conscious and unconscious training, by which we judge whether or not those who speak to us are telling the truth. This important faculty is dependent upon both the senses of sight and hearing. We recognize at once an insincere tone; even dogs and children judge us in an occult and unknown manner. By the use of the eye, as well as the ear, we unconsciously interpret all messages that come to us as exaggerated, true or false. That ancient requirement of the law that "the accused must be confronted by the witness against him" was no doubt in some measure based upon this important faculty by which truth is separated from falsehood. A witness should be placed close to and nearly, if not quite, facing the jury or the judge who is to decide upon the truth or falsity of his testimony, and the room should be so lighted that his attitude, appearance, and every changing expression is distinctly seen. Few of us have ever analyzed the evidences of sincerity and of untruthfulness as shown by hearing and sight, but we can understand how, at least to some extent, it can be done.

A visit to many a court-room is sufficient to show how such a room should not be arranged and should not be lighted. Artistic and architectural considerations, in many cases, would seem to be the only ones that had been consulted in the arrangement. In many a city of our land, of all places, the court-room is the one place where it is most difficult to hear and the most difficult to see, and the administration of the law could be greatly aided by the lighting engineer, the ventilating engineer, and the acoustic engineer. Trials should be held where every word spoken can be heard distinctly, and where every piece of visible evidence can be clearly seen for exactly what it is.

There are many court-rooms so dimly lighted and so improperly arranged that it is almost impossible in them to prove forgery when such proof must be based upon the correct interpretation of delicate but highly significant visible evidence. In some few cases court and jury leave their accustomed places and in an informal and sensible manner gather around some low-placed, clean window where all can see and all can hear.

In connection with the proof of many different questions relating to disputed documents, correct and adequate illumination is absolutely essential if the facts are to be proved. Vital evidence is sometimes based entirely upon the interpretation of indistinct stains, or delicate tints or colors which, under the dim light provided, all become a dull and indistinct gray. In cases involving chemical erasures, in which certain indistinct yellow stains are of the utmost significance, such evidence is practically invisible under the yellow, flickering artificial light or the dim daylight of the average court-room. In many court-rooms the effective use of a microscope is simply impossible.

In many cases involving the identification of paper, where sheets have been interpolated in disputed documents, the case could be positively proven out in the court-yard, but under the conditions provided, intensified by the bad acoustic properties, injustice may triumph or the guilty may escape. Many a city in this land has spent millions of dollars on a court-house without one properly lighted and well arranged court-room where clear seeing and distinct hearing are possible. Darkness and evil have always been associated and still are associated in many a court-room. The modern laws of some states happily require a certain amount of properly placed light in every school house, but such laws, it would seem, have not yet been applied to the law houses.

Light is also a great aid to justice in connection with the subject of photography as now applied to the investigation and proof of disputed documents. To the modern examiner of disputed handwriting and documents, the photographic camera bears a relation to the business similar to that of the compass to the mariner. The relation of light to this question of photography is as close as the etymology of the word itself suggests. It writes out in a universal language its unmistakable interpretation of many things. Many disputed document cases are hastily settled as soon as they are properly illuminated by the photographic camera.

The camera assists us to see certain things which, without its aid, are too small for us to recognize in their true significance and force. It is one of the natural but erroneous human assumptions that we see all that exists before us; but we know that this is not true, and thus arises the necessity, in connection with many questions, of properly enlarging the thing to be observed. Many forgeries are perfectly apparent when enlarged a few diameters. The photograph also makes it possible to cut apart, group, and arrange the parts of a disputed document for effective study and comparison.

As is well known, the whole photographic art is based upon the arrangement and control of light, and certain hidden facts in a forgery can be clearly shown in a photograph by certain special arrangements of light. In a laboriously perfected forgery in which the lines have been carefully retouched and overwritten so that under ordinary vision the result seems to be perfect, a transmitted light photograph under proper enlargement is often sufficient to prove the fraud. By this means the varying thicknesses of the ink film itself are measured by measuring its ability to transmit light. If a line is retouched skillfully so that the edges are not broken or disturbed, such additions under ordinary vision may be invisible even under magnification, but a transmitted light photograph of such a stroke, enlarged from four to ten diameters, will show in permanent form with the utmost distinctness every added stroke. In making a photograph of this character the document is lighted partly from the front, but with the strongest light from the back, so that the light which makes most of the photograph is actually transmitted through the paper itself.

The transmitted light photograph is often more effective than the microscope to show retouching, but for preliminary investigations of this kind, and also for direct demonstration in court, the following special application of light is of great aid. A microscope table with a glass top having a strong light close underneath is provided. This combination is very useful, especially when employed in connection with the stereoscopic microscope. An arrangement of this kind in the leading banks of the land, available for instant use, would save thousands of dollars every year, as by its aid an experienced observer, in many cases, is literally able to "see through" a forgery. By this means light is literally thrown on the subject.

Another condition under which special illumination is of great value is in the interpretation of certain kinds of erasures, especially erasures of pencil lines. The disposition of thousands of dollars may depend upon the interpretation of a few words or even a few figures and the determination as to whether or not they have been changed. Unlike an ink line, an ordinary pencil mark is made by sufficient pressure on the writing instrument,

* A paper read at the eighth annual convention of the Illuminating Engineering Society, Cleveland, O.

so that a certain amount of graphite is worn off against the surface of the paper. If a mark of this nature is carefully erased so that the coloring matter is removed, it may become entirely illegible although the depression still remains, but is so shallow that it is invisible even under the microscope. If, however, such an erasure is photographed in enlarged form, with a strong illumination through a narrow slit on one side with the rays of light almost parallel with the surface of the paper, the shallowest depression, where a word or figure has been so effectually erased that it is totally invisible under any other examination, then produces a shadow which, in a photograph of this kind, sometimes shows with absolute distinctness what was originally written.

Another class of cases under which the question of perfect illumination is of vital importance is in all ink investigations, either to determine age, or to discover whether two or more ink writings are identical or different. Some of these questions can no more be answered under the illumination of certain court-rooms than they could be answered in the light of the average cellar; while the same investigation, if conducted under properly diffused white light, shows a result that can be seen and appreciated by any intelligent man. It is easy to understand how desirable it may be under certain circumstances to show that writing is not as old as it purports to be, or to show that an addition or interlineation in ink is the same or different from other parts of the same document. The interpretation must be based mainly upon the recognition of certain colors. Under suitable conditions and proper lighting this recognition is possible with the average observer. In many court-rooms such facts cannot be proved.

All ordinary commercial ink of the present day is a chemical solution to which a temporary blue color is added, so that the writing may be legible when first written. Fresh writing of this kind, as we are all aware, is of a distinct blue or bluish green color, which color gradually disappears as it is submerged or masked by the development of a stronger color from the chemical constituents of the ink, until it finally reaches a black or neutral gray. When used during the winter months, modern ink, under the usual conditions under which writings are kept, requires many months to lose all its initial blue color, so that examinations like those described, to show that the ink is not as old as it purports to be, may be made a long time after the actual date of the writing. Wills and documents representing hundreds of thousands of dollars are brought into courts of law purporting to be many years of age, on which the ink color has not yet reached its ultimate degree of blackness or intensity.

By the use of a special color microscope with two objectives and the Lovibond tintometer glasses it is possible to match and record this changing ink color with great accuracy. For example, it is easily possible to match more than a thousand variations in the color blue alone. If an ink of this class is accurately matched and recorded as it first appears on a document purporting to be several years of age, and then the same portion of ink is observed under the same conditions a few days or weeks afterwards, and the ink has distinctly changed from a blue or distinct purple to a black or a much darker color, this is positive proof that such document is not as old as it purports to be. Most persons can recognize colors under favorable conditions, but the recognition and matching of colors in an investigation of this kind in the ordinary court-room, under the conditions ordinarily provided, is simply impossible. If evidence of this class is to be made use of, it is necessary that the ink should be observed under diffused white light of the proper intensity.

Another most interesting special application of light that promises to assist in disputed document cases makes use of those strange new rays of the spectrum out beyond the violet. By the use of a suitable screen and appropriate illumination it is possible to photograph totally invisible stains resulting from a chemical erasure, so that the original writing becomes entirely legible.

Thus we see the advancement of knowledge in every field supplements that in every other field, and light engineers may be of great service in illuminating dark places in various divisions of human activity.

The Engineer and the Map of the World*

THE one certainty regarding the result of the present war is that the map of the world will be greatly altered. The changes will concern the boundary lines of different nationalities, and will therefore be political. Even although the engineer has exercised great influence in providing the munitions of war which have so greatly assisted in the accomplishments which will inevitably lead to such changes, our purpose in writing now on the subject is rather to point to the material alterations in the map of the world resulting directly from the work of the engineer. By his agency land is converted into water and water into land. Rivers regularized and deepened, and artificial canals, affect the extent to which water-borne traffic can penetrate into the interior of countries. Railways, roads, and tramways have in other cases superseded rivers. Railways and roads are constructed, and traverse bridges across straits, whereby islands become ostensibly part of the mainland. Waterways are cut through isthmuses to connect oceans. By afforestation and deforestation vast changes are also made on the face of the earth, and through these and other agencies, influence is exerted on the climatic conditions, whereby the land is made more or less fruitful, the temperature being affected and the degree of moisture in the air altered. The health of districts is, by the same media, improved directly, while the advent of the engineer in many parts of the world brings in its train the scientist, with his investigation and work to combat fatal diseases, such as malaria, yellow fever, and the like. One has but to remember the improvement in the health conditions of Ismailia and at Panama to realize the immense consequence following the presence of the bacteriologist in association with the engineer. Mountains, deserts, and rivers have had their significance minimized by the advance of engineering. Mountains have been pierced, rivers bridged, deserts watered by irrigation, and forests removed or planted. Following tree-planting comes ploughing and harrowing and harvesting, and the desert blossoms like the rose. Industrial communities arise to meet the needs of the agricultural workers, and these again bring railways and other changes. Indeed, the practical every-day facts of the map take on a new meaning, owing to the advance of modern science. The term miles, for instance, has not the same significance as under the older forms of transport. To-day distances must be measured rather by the time necessary to get from point to point. Again, even such island empires as Britain and Japan may lose their isolation if tunnels are made, and submarine and aerial ships become tenable, for ordinary commerce.

In view of the war there is appropriateness in the suggestion of lack of finality in the work of those concerned with the political changes on the map of the world as compared with the continuous and permanent influence exerted by the engineer on geography. The presidential address, delivered to the Geographical Section of the British Association by Sir Charles P. Lucas, K.C.B., K.C.M.G., although prepared without any conception of the present international crisis, has an appositeness which is peculiarly impressive, as it deals with man as a geographical agency. It dealt with man's work in such departments of activity as irrigation, land reclamation, reservoir building, afforestation, etc. The damming of the Nile at Assouan, making a lake 65 square miles in area, with its immense practical, if not also political, advantage to the Soudan and Egyptian deserts, was referred to by Sir Charles Lucas. There was also indicated the corresponding irrigation work in India, which, in 1903, watered something like 68,750 square miles, a larger area than England and Wales together. Sir William Willcocks's work now in progress on the Euphrates and the Tigris, for irrigating nearly 19,000 square miles, at once rises to memory in this connection, while 4,000 square miles of the plains between the White and Blue Nile are to be watered artificially for cotton culture by the construction of a dam, and of a 100-mile canal south of Khartoum. In Australia, again, great work is being done to the same end. Already the works completed and in process of construction irrigate over 600 square miles in Victoria alone; but when the whole water supply of the State is utilized, more like 6,000 square miles will be irrigated. The Burren-juck scheme, in New South Wales, will irrigate, in the first instance, not far short of 500 square miles, but may eventually be made available for six times that area. In the Algerian Sahara desert nearly 22,000 square miles have been reclaimed with water from artesian wells. These facts show what has been done, and give confidence in the belief that still greater achievements will effect still more extensive changes on the face of the earth. By tree barriers in the sand dunes, whereby the moisture of the soil is preserved, fine crops of durum wheat, it was further pointed out by Sir Charles, are got without a drop of rain from seed time to harvest. In the Landes of Gascony 3,600 square miles of sandy waste have thus been planted with trees. The influences of all such works to assist agriculture is not only direct, but there is a great indirect gain; a consequence is the settlement of a population more or less extensive, due not only to the winning of the produce of the land irrigated, but to the creation of railways and factories for meeting the needs of the people. In this way, as the stories of Canada, South Africa, and Australia testify, communities are built up, and new nations grow steadily in prosperity.

The map has also been changed by great reservoirs for the water supplies of cities—Thirlmere, Vyrnwy, Loch Katrine, and those for Birmingham are cases in point. In the last session of Parliament there was vigorous opposition to the flooding of one of the historic districts of Scotland further to augment the water supply to the city of Glasgow. Abroad there are many similar instances, the most recent being the formation of a great dam on the Murrunbidgee River for New South Wales, to make a lake forty-one miles long, and the Catskill Reservoirs for the supply of New York, recently fully illustrated and described in *Engineering*. In his address, Sir Charles Lucas referred also to the importance of natural waterways, the Clyde, the Tyne, and other such streams, on whose banks there have been created great factories to produce articles for export through the waters of such rivers to the farther ends of the earth.

In the reclamation of land the engineer has exercised an equally great influence on the map. That the engineer in such work has greatly affected geography is proved by the example of London alone, since the metropolis is built partly on marshy land. Some city names, indeed, prove this, notably Moorfields and Finsbury (or Fensbury). With the work begun in the sixteenth century that part of the city has been recovered from the marsh lands. Pimlico is largely built on piles, and in the region now occupied by Belgrave Square snipe shooting was a sport three or four generations ago. The names of the Strand and Fleet Street also carry their significance. Even in new countries there are analogous cases. Harbors, such as that at Wellington, in New Zealand, have been partly reclaimed from the sea. Sir Charles Lucas also referred to the work done in the Lincolnshire Fens, where land variously estimated in extent from 800 to 1,200 square miles has been recovered or improved. Another instance of reclamation at home is to be found on the famous Romney Marsh, in Kent. Abroad one of the most extensive cases is that in the Netherlands, where there has been a constant change between land and water area; the Dutch people have steadily worked toward reclamation, and even at the present time the progress of the scheme for draining the Zuyder Zee proves the far-sighted policy of the government. The scheme is to be carried out in thirty-three years at a cost of nearly $80,000,000, and will result in an addition of 815 square miles of land to the kingdom, 750 miles of which will be fertile, while at the same time a much-needed fresh-water lake, with an area of 557 square miles, will be formed and will be fed by one of the mouths of the Rhine. Between the Elbe and Scheldt more than 2,000 square miles have been reclaimed from river and sea in the past three hundred years.

Touching upon afforestation, Sir Charles Lucas did well to point out, as did Mr. G. B. Marsh fifty years before him, that man has too long forgotten that the earth was given him for usufruct alone, not for consumption, still less for profligate waste. The sweeping away of great forests, a practice even more pursued to-day than ever before, is undoubtedly the eating up of capital. Apart altogether from the value of the timber, trees give shelter against the wind, store water, prevent inundation, and preserve and enrich the soil. It is true that experience in the south of France has proved that the pasturing of sheep is as great a destroyer of forests as man, because they break the soil and expose the roots, so that rainstorms and floods sweep away the soil. This may easily be remedied, but the cutting away of the timber without replanting of trees is reprehensible. It has been suggested that, in view of the possible degree of unemployment in this country consequent on the present unsettled state of affairs, the British government might utilize the occasion for carrying into effect the afforestation scheme approved by a recent commission of inquiry, a point not enforced by Sir Charles Lucas. This proposal, it will be remembered, aimed at the planting annually of 150,000 acres of suitable land, and the result might probably be a valuable source of revenue ultimately for the government. It is thought this would afford temporary employment to men out of work and not suited for the army, while permanently many men could be utilized directly in connection with the forests and indirectly with the subsidiary industries. The commissioners estimated that the annual cost would be two millions sterling, and each year there would be an increasing deficit in working operations for the next forty years. Then revenue would be derivable. From this date onward the commissioners estimated that the deficit would steadily decrease, until in eighty years there would be, from 9,000,000 acres of forest then existent, a net revenue of about $87,000,000. The scheme thus expressed is seductive, but the figures are only estimates. That we are deficient in forest lands is

* From *Engineering*.

shown by the fact that the proportion to the total area of the country is 5.3 per cent, as compared with 32.6 per cent in Austria, 17.3 per cent in Belgium, and 17 per cent in France. At present, under the auspices of Birmingham University, and under the presidency of Sir Oliver Lodge, the Midlands Reafforestation Association is planting the pit-mounds and ash quarries of the Black Country with trees which will resist smoke and bad air—alders, willows, poplars—carrying out their work, a report says, under a combination of difficulties not to be found in any other country. Thus, apart from the direct gain in the growth of timber, the work of afforestation confers great indirect advantages, [illegible] serves further to prove that from first to last the [illegible] neer is exercising an important influence on the [illegible] the world, as well as upon the significance of geog[illegible] ical terms. Sir Charles Lucas has done well once [illegible] to direct attention to these important considerati[illegible]

Explosives*

The Various Materials Employed and Methods of Using

An explosive is a body which, under the influence of heat or shock, or both, is, speaking popularly, instantaneously resolved entirely, or almost so, into gases.

Practical explosives consist either of bodies such as nitroglycerine and nitrocellulose, which are explosive in themselves, or mixtures of ingredients which separately are, or may be, non-explosive, but when intimately mixed are capable of being exploded.

Explosives are exploded either by simple ignition, as in the case of black gunpowder, or by means of a detonator containing mercury fulminate.

The molecules of an explosive may be regarded as in a state of unstable chemical equilibrium. A stable state of equilibrium is brought about by the sudden decomposition of the original compounds with the evolution of heat. An explosion is thus an extremely rapid decomposition, accompanied by the production of a large volume of gas and the development of much heat.

There are two well-defined modes of explosion which can be described as combustion and detonation. In the former case, the explosive is simply ignited and combustion takes place by transference of heat from layer to layer of the explosive. The rapidity with which the combustion proceeds depends not only on the physical form of the explosive, but also on the pressure under which the decomposition takes place. When in the form of fine grains, combustion proceeds much more quickly than when the grains are large, and the powder maker takes advantage of this fact in preparing powder for rifles and the various sized large guns.

Detonation, on the other hand, has to be started by a sufficiently strong impulse, such as the explosion of a charge of mercury fulminate; it proceeds much more rapidly and is due to the formation of an explosion wave that has a velocity of thousands of meters a second.

Black gunpowder and allied explosives, as well as the smokeless powders, belong to the first or combustion class, and they are commonly designated "low" explosives.

"High" explosives indicate those, such as dynamites and nitrate of ammonia explosives, which detonate and have a greater shattering action than the former.

The volume and composition of the gas produced, both in regard to the power of the explosive, and, in the case of mining explosives, the health of the miner, are of great importance. These gases are largely determined by the original composition of the explosive.

When there is insufficient oxygen for complete oxidation, the products are carbon dioxide, carbon monoxide, hydrogen, water, and nitrogen, but the relative proportions vary with the pressure developed. When such an explosive is fired in a closed vessel under different densities of charge, that is, different quantities of explosive in the same volume, the volume and composition of the gas varies with the pressure developed by the explosion. The carbon dioxide and hydrogen increase and the carbon monoxide and water diminish as the pressure increases; also, at high pressures, considerable amounts of methane are formed. In the foregoing, it has been assumed that complete explosive decomposition has taken place.

When a high explosive burns, instead of explodes, the chemical changes are not only very much slower and the disruptive effect practically *nil*, but the character of the gases is entirely changed, large volumes of poisonous nitrous fumes along with other gases being produced.

The temperature developed by an explosive is of importance, because the higher the temperature the greater the erosion of the guns.

Nearly all blasting explosives, except black powder, are fired by means of a detonator. Fulminate of mercury is the most widely employed constituent of the detonator charge; sometimes it is used alone, but more usually with an admixture of 20 per cent of potassium chlorate.

Trinitrotoluene, picric acid, and tetranitromethylaniline, each with a small quantity of fulminate as primer, have also been used for charging detonators.

More recently lead azide prepared from the sodium salt of hydrazoic acid N_3H, by means of a lead salt, has also been used, as it has a greater power of initiating detonation, so that less azide is required to detonate an organic explosive than would be required of fulminate. Its manufacture, however, is more delicate than fulminate, and the formation of large crystals must be avoided, as they have the unpleasant property of sometimes exploding spontaneously.

Another new explosive body which appears likely to play an important part as a charge for detonators is tetranitroaniline, manufactured by nitrating metanitroaniline. It combines an exceptional explosive power with aromatic stability and has a high density.

It can be easily detonated, even when highly compressed, and has such a high percentage of oxygen that it can be detonated without residue or smoke.

In blasting operations, gunpowder and detonators are either fired by a time fuse or electrically. The time fuse consists of a thin but continuous core of black powder covered by a case of twine and tape and varnish. It is made to burn at a known uniform rate, generally 2 feet a minute, in order that a sufficient length can be used to allow the shot-firer, after lighting the fuse, to reach a place of shelter before the explosion takes pl[illegible]

The instantaneous fuse, which burns at the ra[illegible] 100-300 feet a second, affords a means of firing m[illegible] charges simultaneously.

Occasionally it happens that a coil is defective, g[illegible] ally through discontinuity in the powder core. C. N[illegible] Hake, late Chief Inspector of Explosives for Vic[illegible] ingeniously employed X-ray photography to exam[illegible] suspected coils, and, in this way, was able to recog[illegible] those which were defective.

One of the most interesting recent productions i[illegible] "detonating fuse," a soft metal tube filled with trini[illegible] toluene which detonates with greater velocity than m[illegible] explosives. When placed alongside the cartridges i[illegible] deep borehole, it is considered to give an enhanced bl[illegible] ing effect by causing the whole charge to go off m[illegible]

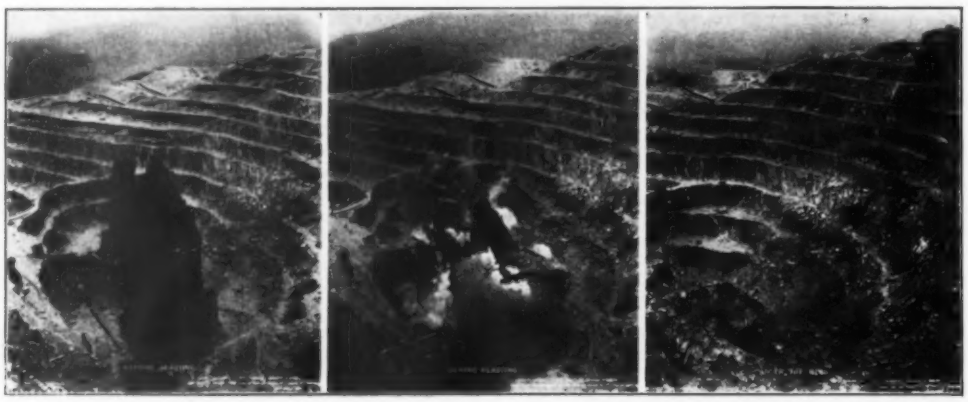


Fig. 1.—Blast at Lord Penrhyn's slate quarries.

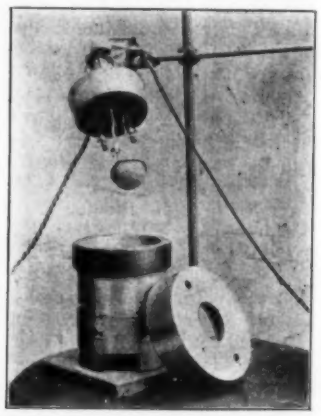


Fig. 2.—Berthelot calori-metric bomb.

Fig. 4.—"Mounded" house, Cotton Powder Works.

simultaneously than when the column of explosiv[illegible] fired at one end by a detonator in the usual way.

With the object of preventing accidents so far [illegible] possible, and minimizing the loss of life should an [illegible] plosion occur, a number of rules and regulations ha[illegible] been drawn up by the Explosives Department of th[illegible] Home Office which have to be followed in the construct[illegible] and working of explosive factories.

The object of the restrictions is to allow only limit[illegible] quantities of explosive material and a limited number [illegible] work-people in one building at a time, and, further, [illegible] place the different buildings at such distances from ea[illegible] other, or surround them by protecting earth mound[illegible] that in the event of an explosion the effect is localis[illegible] as much as possible and the explosives in the adjace[illegible] buildings are not "set-off."

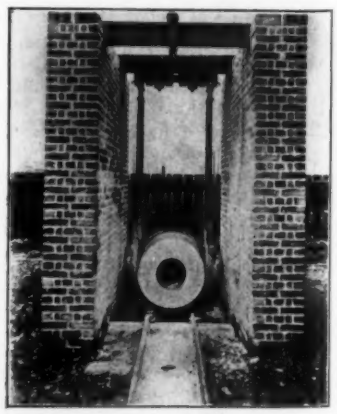


Fig. 3.—Ballistic pendulum, Home Office testing station.

The manufacture of guncotton and the other forms of nitrocellulose is carried out in the first stages in the non-danger part of the factory.

The most interesting development of the nitration process is the method devised by J. and W. Thomson, of the Royal Gunpowder Factory, Waltham Abbey.

The composition of the acid mixture is of the greatest importance and largely determines the character of the

* From a course of lectures delivered before the Institute of Chemistry, at King's College, London, by Mr. William Macnab, and published by the Institute. Reproduced from *Nature*.

uct. The ratio between the nitric and sulphuric and the water must be accurately adjusted.

must also be remembered that the cotton is by no s a definite chemical body, and its physical state an important part. Samples of different cottons, r the same conditions in a bath of the same com- ion, while yielding nitrocelluloses containing prac- ly the same percentage of nitrogen, may vary in ility in ether-alcohol from 25 per cent to 70 per

urning now to the production of nitroglycerine, this ufacture is much simpler than that of nitrocellulose; e same time, it is much more dangerous.

he plant which is at present most employed is known e nitrator-separator. It was developed at Waltham y by Sir Frederic Nathan and W. Rintoul, and is a t advance on the former methods.

he nitrator-separator is a cylindrical leaden vessel a coned top; inside are placed leaden coils, through h cooling water circulates, and pipes, through which pressed air is blown to mix the contents. The erine is introduced in the form of a fine spray under acid by means of a special injector, worked also by pressed air.

hen everything goes right, the nitration of the charge ually completed in about one hour; the agitation h the air is discontinued and the separation of the roglycerine from the acids takes place—being lighter omes to the top. A pipe, in which a glass window is ed, leads from the top of the nitrator-separator to a washing tank; by allowing waste acid from a previous ration to enter at the bottom, the nitroglycerine is ed over into the washing tank; and the flow of acid topped whenever all the nitroglycerine has passed into washing tank, which can be observed through the ndow.

With the object of preventing explosions of gas or coal-dust in mines, our Government, in common with many others, has instituted a test which explosives have to pass before they are put on the "permitted" list, and are available for use in fiery or dusty mines. This test has varied in the different countries, and a change has been introduced recently, since the transference of the testing station from Woolwich to Rotherham. Much difference of opinion still exists as to the best means of carrying out such a test.

One of the chief factors in determining the ignition is the temperature developed by the gases of explosion. Owing to lack of data, the temperature cannot be calculated with sufficient accuracy, and other conditions obtain which make a practical test more helpful. Nevertheless, the temperature is of great importance and many means are employed of lowering it, such as adding salts which absorb heat on volatilization.

The rapidity of detonation, the length of the flame, and the heat evolved, all influence the readiness with which explosives ignite gas or coal-dust; but in this connection knowledge and progress have been chiefly promoted by direct experiment at the various testing stations here and abroad.

The filling material for shells has been the subject of much experiment and trial by the different countries. Picric acid, under the various names of melinite, lyddite, shimose powder, etc., has been extensively tried and found wanting. Ammonal, containing ammonium nitrate, with a large percentage of trinitrotoluol and finely divided aluminium, is a very safe and powerful explosive, and has been adopted as the charge for shells by the Austrian government. It has the disadvantage of containing the hygroscopic ammonium nitrate as an ingredient, and must consequently be specially protected against moisture. At present, trinitrotoluol is the body which has commended itself to most of the governments as the best bursting charge for shells, torpedoes, and general military blasting work, and has just been adopted by our own government.

Experience in America, South Africa, and Australia has shown that the fruit-grower has a real friend in explosives, and it seems to me that, in this country also, we must wake up to this beneficent aspect of explosives and the means they offer of attaining results otherwise impossible.

In the case of tree planting, it is not the mere comparison of the cost of the excavation of the hole in which to place the tree which has to be considered. When an explosive is employed, the soil is shaken up and fissured for a comparatively wide area beyond the hole actually required for the tree. When, as often happens, there is a hard and impervious subsoil beyond reach of the spade, this is also opened and fissured, and experience has shown that trees planted in ground prepared by explosives make a much more vigorous and rapid growth than when planted in the ordinary way. Some trees have begun bearing after four years, while others similarly situated but spade planted did not yield fruit until six years, certainly a good return for the investment.

In the case of existing orchards little can be done in the ordinary way to aerate or render the soil more pervious to the roots and moisture, but a small cartridge inserted at some depth below the tree, or a larger one exploded at a depth of 3 feet or so below the surface and midway between trees planted about 15 feet apart, has a most beneficial effect in loosening the soil without injuring the trees. The roots have less resistance to overcome, the soil is aerated, the moisture retaining properties improved, and a new lease of life is thus given to an old orchard; the trees become more vigorous and productive, and indeed are rejuvenated.

Death of the Last of the Wild Pigeons

By R. W. Shufeldt, M. D.

Many years ago, the Cincinnati Zoological Company s so fortunate as to have no fewer than eight living ecimens of the Passenger Pigeon (*Ectopistes migra- rius*) in its gardens. From time to time these died, d were doubtless disposed of in one way or another til, finally, there remained of the little flock only a ngle female bird. As they passed away, the same ecies was being rapidly exterminated in nature, until e day it became evident to everyone who knew any- ing of such matters that the wild pigeon had become tinct. Man had eliminated it from the face of the rth. Rewards were then offered for specimens, and ese became more substantial, as the fact was clearly preciated that the "blue pigeons" were among the ings of the past. Finally, a thousand dollars were ld out as an inducement to any person who could cate a nest with a fresh clutch (2) of eggs in it, and rnish that information to the party offering the re- ard. This brought many "finds" in; but they all oved to be either mourning doves or band-tailed geons, and at last it became very evident that not a ngle Passenger Pigeon was left at large in the coun- y, where formerly they migrated in flocks of billions.

Meanwhile the sole survivor, the female in the Cin- nnati "Zoo," lived on, until the term of its captivity as an unusually long one for any wild bird deprived its liberty, outside of certain species, such as the rrots and others. But the end was sure to come; and t last, after it had survived for twenty-nine long years, succumbed to what was, apparently, nothing more an advanced age. This occurred at 1 o'clock in the rning on September 1st, 1914, and the body, as had en previously arranged, was sent to the Smithsonian stitution in Washington, in that science might make e best possible use of it. It fell to me to take part in is, and through the courtesy of C. W. Richmond, sistant curator of birds of that institution, I arrived t the room in the National Museum about one hour fter the arrival of the specimen (September 4th, 1914).

At my request, it was first taken to the photographic llery, where I posed it in the three conventional pects (anterior, posterior, and lateral) for the pur- se of taking its picture, and that number of 8 by 10 gatives were successfully made. From there, it was t once taken to my home, 3356 Eighteenth Street, ashington, D. C., by Mr. William Palmer of the Smith- nian Institution, who had been delegated to skin it r the taxidermist, who was absent from the city at e time of the arrival of the specimen. While Mr. lmer was thus engaged in one of my work-rooms, I as in my dark-room, developing several negatives hich I had previously made of the bird with my own mera (5 by 8), namely, two of its head, natural size, nd one of the torso, before the skin had been com- letely removed.

Before Mr. Palmer took his leave, he carried out Dr. Richmond's directions, and turned over to me the body of the bird, for anatomical dissection and description. This latter labor, including the making of other negatives and a colored plate, has all been completed, and early next year my report thereon will be duly published in another connection.

Side view of the head of the last Passenger Pigeon.

The side view of the head, which illustrates the present brief article, is a reproduction of one of my own photographs of the specimen—one of those taken at my home, as mentioned above. It is natural size, and I restored the eye in that the portrait might have a more life-like appearance. When Mr. Nelson R. Wood, the veteran taxidermist of the Smithsonian Institution, returns to duty, the specimen will be duly mounted for the Ornithological Exhibition Rooms of the National Museum, where it will be sure to attract very considerable interest on the part of the visiting public.

It is to be hoped that it may, in time, have some little influence in staying the hand of man in his career of extermination of such incomparably beautiful creatures in nature. I, for one, greatly fear that this will not be the case. In due course, the day will come when practically all of the world's avifauna will have become utterly extinct. Such a fate for it is coming to pass now, with far greater rapidity than most people realize.

Tsing-Tau, Germany's Eastern Colony

Not much accurate information exists as to the ability of Germany's naval base in the Far East to resist a vigorous attack from the sea, but the position is one of great natural strength and importance. The Bay of Kiao-Chau, on the northeast shore of which it stands, together with the surrounding district, was seized by Germany in November, 1897. Early in that month two German missionaries were attacked and killed while traveling in the Province of Shantung, and a few days later the Kaiser's Pacific squadron anchored in the estuary, an ultimatum being sent to the Chinese general to leave with his troops within three hours. He did so under protest; the German flag was hoisted, and after negotiations with Pekin the matter was settled in March, 1898, by the leasing of the bay and territory to the Emperor for ninety-nine years.

The district thus acquired by force amounted to some 200 square miles, and with its land-locked harbor has been described as the key to Northern China, Lord Charles Beresford being among those who have expressed the opinion that it represents one of the most important naval bases on the Chinese coast.

Facing the Yellow Sea, about 350 miles in a direct line southeast of Pekin, and almost opposite the southern extremity of Korea, the bay of Kiao-Chau is less than two miles wide at its entrance. Within it extends over an area of something like 150 square miles of deep water affording at all times a safe anchorage for ships of any size. The inlet is entirely surrounded by hills from 400 feet to 600 feet high, most of them offering admirable sites for fortifications. If the defensive works planned when the place was seized have been carried out and fully armed, the harbor must present formidable obstacles to a sea attack, while the land approaches are guarded by a series of fortifications across the head of the peninsula. The garrison consists of 5,000 German marines and a small force of Chinese soldiers, the remainder of the white population being very inconsiderable.

The immediately surrounding district is rich in mineral and metalliferous deposits, a large but undeveloped supply of coal being one of the inducements which led the Germans to fix on Kiao-Chau for settlement. Other local industries are connected with fruits and vegetables, silk culture, brewing, and soapmaking. Two years ago the imports amounted in value to 114,938,000 marks, and the exports to 80,295,000 marks. In the winter months the harbor is the natural outlet for the trade of Northern China, a railway, 272 miles long, from Tsing-Tau to Poshan, having much increased its value in this direction. The German war vessels in Chinese waters, as well as a large number of German trading ships are probably sheltering under the Tsing-Tau heights at the present moment.—*The Daily Telegraph, London.*

Cosmical Physics*

The Effect of the Law of Gravitation Applied to the Moon

By Prof. E. W. Brown, F.R.S.

WHEN a comparison between the work of the lunar theorist and that of the observer has to be made, it is necessary to take into consideration the facts and results obtained by astronomers for purposes not directly connected with the moon: the motions of the earth and planets, the position of the observer, the accuracy of star catalogues, the errors of the instruments used for the measurement of the places of celestial objects, the personality of the observers—all these have to be considered; in fact, almost every one of the departments of the astronomy of position must be drawn upon to furnish necessary data. The time has now arrived when it may perhaps be possible to repay in some measure the debt thus contracted by furnishing to the astronomer, and perhaps also to the student of geodesy, and, if I may coin a word, of selenodesy, some results which can be deduced more accurately from a study of the moon's motion than in any other way. A long-continued exploration with few companions which ultimately leads to territories where other workers have already blazed paths gives the impression of having emerged from the thick jungle into open country. The explorer can once more join forces with his brother astronomers. He can judge his own results more justly, and have them judged by others.

If, then, an excuse be needed for overstepping the limits which seem, by silent consent, to have been imposed on those who devote themselves to lunar problems, it consists in a desire to show that these limits are not necessary, and that a study of the motion of the moon can be of value and can contribute its share to the common funds of astronomy. The history of the motion of the moon has been for more than two centuries a struggle between the theorists and the observers. Ever since the publication of the "Principia" and the enunciation of the law of gravitation by Isaac Newton, a constant effort has been maintained to prove that the moon, like the other bodies of the Solar System, obeyed this law to its farthest consequences. While the theory was being advanced, the observers were continually improving their instruments and their methods of observing, with the additional advantage that their efforts had a cumulative effect: the longer the time covered by their observations, the more exact was the knowledge obtained. The theorist lacked the latter advantage: if he started anew he could only use the better instruments for analysis provided by the mathematician. He was always trying to forge a plate of armor which the observer, with a gun whose power was increasing with the time, could not penetrate. In the struggle, the victory rarely failed to rest with the observer. Within the last decade we theorists have made another attempt to forge a new plate out of the old materials; whether we have substantially gained the victory must rest partly on the evidence I have to place before you to-day, and partly on what the observer can produce in the near future. There are three well-defined periods in the history of the subject as far as a complete development of the moon's motion is concerned.

From the publication of the "Principia," in 1687, when Newton laid down the broad outlines, until the middle of the eighteenth century, but little progress was made. It seems to have required over half a century for analysis by symbols to advance sufficiently far for extensive applications to the problems of celestial mechanics. Clairaut and d'Alembert both succeeded in rescuing the problem from the geometrical form into which Newton had cast it, and in reducing it to analysis by the methods of the calculus. They were followed by Leonard Euler, who, in my opinion, is the greatest of all the successors of Isaac Newton as a lunar theorist. He initiated practically every method which has been used since his time, and his criticisms show that he had a good insight into their relative advantages. A long roll of names follows in this period. It was closed by the publication of the theories of Delaunay and Hansen, and the tables of the latter, shortly after the middle of the nineteenth century. From then to the end of the century, the published memoirs deal with special parts of the theory, or with its more general aspects, but no complete development appeared which could supersede the results of Hansen. My own theory, which was completed a few years ago, is rather the fulfilment to the utmost of the ideas of others than a new mode of finding the moon's motion. Its object was severely practical—to find in the most accurate way and by the shortest path the complete effect of the law of gravitation applied to the moon. It is a development of Hill's classic memoir of 1877. Hill in his turn was indebted to some extent to Euler. His indebtedness would have been greater had he been aware of a little-known paper of the latter, "Sur la Variation de la Lune," in which the orbit, now called the variation orbit, is obtained, and its advantages set forth in the words: "Quelque chimérique cette question j'ose assurer que, si l'on réussissoit à en trouver une solution parfaite on ne trouveroit presque plus de difficulté pour déterminer le vrai mouvement de la Lune réelle. Cette question est donc de la dernière importance, et il sera toujours bon d'en approfondir toutes les difficultés, avant qu'on en puisse espérer une solution complète." In the final results of my work, the development aims to include the gravitational action of every particle of matter which can have a sensible effect on the moon's motion, so that any difference which appears between theory and observation may not be set down to want of accuracy in the completeness with which the theory is carried out. Every known force capable of calculation is included. So much for the theory. Gravitation, however, is only a law of force: we need the initial position, speed, and direction of motion.

To get this with sufficient accuracy no single set of observations will serve; the new theory must be compared with as great a number of these as possible. To do this directly from theory is far too long a task, and, moreover, it is not necessary. In the past, every observation has been compared with the place shown in the Nautical Almanac, and the small differences between them have been recorded from day to day. By taking many of these differences and reducing them so as to correspond with differences at one date, the position of the moon at that date can be found with far greater accuracy than could be obtained through any one observation. At the Greenwich Observatory, the moon has been observed and recorded regularly since 1750. With some 120 observations a year, there are about 20,000 available for comparison, quite apart from shorter series at other observatories. Unfortunately, these observations are compared with incorrect theories, and, in the early days, the observers were not able to find out, with the accuracy required to-day, the errors of their instruments or the places of the stars with which the moon was compared. But we have means of correcting the observations, so that they can be freed from many of the errors present in the results which were published at the time the observations were made. We can also correct the older theories. They can be compared with the new theory and the differences calculated: these differences need not ever be applied to the separate observations, but only to the observations combined into properly chosen groups. Thus the labor involved in making use of the earlier observations is much less than might appear at first sight. For the past eighteen months, I have been engaged in this work of finding the differences between the old theories and my own, as well as in correcting those observations which were made at times before the resources of the astronomer had reached their present stage of perfection. I have not dealt with the observations from the start. Other workers—notably Airy in the last century, and Cowell in this—have done the greater part of the labor. My share was mainly to carry theirs a stage further by adopting the latest theory and the best modern practice for the reduction of the observations. In this way, a much closer agreement between theory and observation has been obtained, and the initial position and velocity of the moon at a given date are now known with an accuracy comparable with that of the theory. I shall shortly return to this problem and exhibit this degree of accuracy by means of some diagrams which will be thrown on the screen.

I have spoken of the determination of these initial values as if it constituted a problem separate from the theory. Theoretically it is so, but practically the two must go together. The increase in accuracy of the theory has gone on successively with increase in accuracy of the determination of these constants. We do not find, with a new theory, the new constants from the start, but corrections to the previously adopted values of these constants. In fact, all the problems of which I am talking are so much interrelated that it is only justifiable to separate them for the purposes of exposition. Let us suppose that the theory and these constants have been found in numerical form, so that the position of the moon is shown by means of expressions which contain nothing unknown but the time. To find the moon's place at any date, we have then only to insert that date and to perform the necessary numerical calculations. This is not done directly, on account of the labor involved. What are known as "Tables of the Moon's Motion" are formed.

These tables constitute an intermediate step between the theory and the positions of the moon which are printed in the Nautical Almanac. Their sole use and necessity is the abbreviation of the work of calculation required to predict the moon's place from the theoretical values which have been found. For this reason, the problem of producing efficient tables is not properly scientific: it is mainly economic. Nevertheless, I have found it as interesting and absorbing as any problem which involves masses of calculation is to those who are naturally fond of dealing with arithmetical work. My chief assistant, Mr. H. B. Hedrick, has employed his valuable experience in helping me to devise new ways of arranging the tables and making them simple for use. A table is mainly a device by which calculations which are continually recurring are performed once for all time, so that those who need to make such calculations can read off the results from the table.

In the case of the moon, the tables go in pairs. Each term in the moon's motion depends on an angle, and this angle depends on the date. One table gives the value of the angle at any date (a very little calculation enables the computer to find this), and the second table gives the value of the term for that angle. As the same angles are continually recurring, the second table will serve for all time. We can, however, do better than construct one table for each term. The same angle can be made to serve for several terms, and consequently one table may be constructed so as to include all of them. In other words, instead of looking out five numbers for five separate terms, the computer looks out one number which gives him the sum of the five terms. The more terms we can put into a single table, the less work for the astronomer who wants the place of the moon, and therefore the more efficient the tables. A still better device is a single table which depends on two angles, known as a double-entry table; many more terms can usually be included in this than in a single-entry table. The double interpolation on each such table is avoided by having one angle the same for many double-entry tables, and interpolating for that angle on the sum of the numbers extracted from the tables. The problem of fitting the terms into the smallest number of tables is a problem in combinations—something like a mixture of a game at chess and a picture puzzle, but unlike the latter in the fact that the intention is to produce ease and simplicity instead of difficulty. This work of arrangement is now completed, and, in fact, about five sixths of the calculations necessary to form the tables are done. Over one third of the copy is ready for the printer; but, owing to the large mass of the matter, it will take from two to three years to put it through the press. The cost of performing the calculations and printing the work has been met from a fund specially set aside for the purpose by Yale University. A few statistics will, perhaps, give an idea of our work. Hansen has 300 terms in his three co-ordinates, and these are so grouped that about a hundred tables are used in finding a complete place of the moon. We have included over 1,000 terms in about 120 tables, so that there are, on the average, about eight terms per table. (In one of our tables we have been able to include no less than forty terms.) Each table is made as extensive as possible, in order that the interpolations—the bane of all calculations—shall be easy. The great majority of them involve multiplications by numbers less than 100. There are less than ten tables which will involve multiplications by numbers between 100 and 1,000, and none greater than the latter number. The computer who is set to work to find the longitude, latitude, and parallax of the moon will not need a table of logarithms from the beginning to the end of his work. The reason for this is that all multiplications by three figures or less can be done by Crelle's well-known tables or by a computing machine. But Mr. Hedrick has devised a table for interpolation to three places which is more rapid and easy than either of these aids. It is, of course, of use generally for all such calculations, and arrangements are now being made for the preparation and publication of his tables.

The actual work of finding the place of the moon from the new lunar tables will, I believe, not take more time—perhaps less—than from Hansen's tables, as soon as the computer has made himself familiar with them. Fortunately for him, it is not necessary to understand the details of their construction: he need only know the rules for using them. I am now going to show, by means of some diagrams, the deviations of the moon from its theoretical orbit, in which, of course, errors of observation are included. The first two slides exhibit the average deviation of the moon from its computed place for the past century and a half in longitude. The averages are taken over periods of 414 days, and each point of the con-

* At the Australian meeting of the British Association.

tinuous line shows one such average. The dots are the results obtained by Newcomb from occultations; the averages for the first century are taken over periods of several years, and in the last sixty years over every year.

In both cases the same theory and the same values of the constants have been used. Only one empirical term has been take out—the long-period fluctuation found by Newcomb having a period of 270 years, and a coefficient of 13 sec. I shall show the deviations with this term included in a moment. The first point to which attention should be drawn is the agreement of the results deduced from the Greenwich meridian observations and those deduced from occultations gathered from observatories all over the world. There can be no doubt that the fluctuations are real, and not due to errors of observation. A considerable difference appears about 1820, for which I have not been able to account; but I have reasons for thinking that the difference is mainly due to errors in the occultations rather than in the meridian values. In the last sixty years the differences become comparatively small, and the character of the deviation of the moon from its theoretical orbit is well marked. This deviation is obviously of a periodic character; but attempts to analyze it into one or two periodic terms have not met with success.

The number of terms required for the purpose is too great to allow one to feel that they have a real existence, and that they would combine to represent the motion in the future. The straight-line character of the deviations is a rather marked peculiarity of the curves. The actual deviations on a smaller scale are shown in the next slide. The great empirical term has here been restored, and is shown by a broken line. The continuous line represents the Greenwich meridian observations; the dots are Newcomb's results from the occultations before 1750, the date at which the meridian observations begin. With a very slight amount of smoothing, especially since 1850, this diagram may be considered to show the actual deviations of the moon from its theoretical orbit. The next slide shows the average values of the eccentricity and of the position of the perigee. The deviations are those from the values which I have obtained. It is obvious at once that there is little or nothing systematic about them; they may be put down almost entirely to errors of observation. The diminishing magnitude of the deviations as time goes on is good evidence for this; the accuracy of the observations has steadily increased.

The coefficient of the term on which the eccentricity depends is found with a probable error of 0.02 sec., and the portion from 1750 to 1850 gives a value for it which agrees with that deduced from the portion 1850 to 1901 within 0.01 sec. The eccentricity is the constant which is now known with the highest degree of accuracy of any of those in the moon's motion. For the perigee there was a difference from the theoretical motion which would have caused the horizontal average in the curve to be tilted up one end over 2 sec. above that at the other end. I have taken this out, ascribing it to a wrong value for the earth's ellipticity; the point will be again referred to later. The actual value obtained from the observations themselves has been used in the diagram, so that the deviations shown are deviations from the observed value. The next slide shows the deviations of the mean inclination and the motion of the node, as well as of the mean latitude from the values deduced from the observations. In these cases the observations only run from 1847 to 1901. It did not seem worth while to extend them back to 1750, for it is evident that the errors are mainly accidental, and the mean results agreed so closely with those obtained by Newcomb from occultations that little would have been gained by the use of the much less accurate observations made before 1847.

The theoretical motion of the node differs from its observed value by a quantity which would have tilted up one end of the zero line about 0.5 sec. above the other; the hypothesis adopted in the case of the perigee will account for the difference. The mean latitude curve is interesting. It should represent the mean deviations of the moon's center from the Ecliptic; but it actually represents the deviations from a plane 0.5 sec. below the Ecliptic. A similar deviation was found by Newcomb. Certain periodic terms have also been taken out. The explanation of these terms will be referred to directly. The net result of this work is a determination of the constants of eccentricity, inclination, and of the positions of the perigee and node with practical certainty. The motions of the perigee and node here agree with their theoretical values when the new value of the earth's ellipticity is used. The only outstanding parts requiring explanation are the deviations in the mean longitude.

If inquiry is made as to the degree of accuracy which the usual statement of the gravitation law involves, it may be said that the index which the inverse-square law contains does not differ from 2 by a fraction greater than 1/400,000,000. This is deduced from the agreement between the observed and theoretical motions of the perigee when we attribute the mean of the differences found for this motion and for that of the node to a defective value of the ellipticity of the earth. I have mentioned the mean deviation of the latitude of the moon from the Ecliptic. There are also periodic terms with the mean longitude as argument occurring both in the latitude and the longitude. My explanation of these was anticipated by Prof. Bakhuysen by a few weeks.

The term in longitude had been found from two series of Greenwich observations, one of 28 and the other of 21 years, by van Steenwijk, and Prof. Bakhuysen, putting this with the deviations of the mean latitude found by Hansen and himself, attributed them to systematic irregularities of the moon's limbs. What I have done is to find (1) the deviation of the mean latitude for 64 years, (2) a periodic term in latitude from observations covering 55 years, and (3) a periodic term in longitude from observations covering 150 years, the period being that of the mean longitude.

Further, if to these be added Newcomb's deviations of the mean latitude derived (a) from immersions and (b) from immersions, we have a series of five separate determinations—separate because the occultations are derived from parts of the limb not wholly the same as those used in meridian observations. Now all these give a consistent shape to the moon's limb referred to its center of mass. This shape agrees qualitatively with that which may be deduced from Franz's figure. I throw on the screen two diagrammatic representations of these irregularities obtained by Dr. F. Hayn from a long series of actual measures of the heights and depths of the lunar formations. The next slide shows the systematic character more clearly. It is from a paper by Franz. It does not show the character of the heights and depths at the limb, but we may judge of these from the general character of the high and low areas of the portions which have been measured, and which extend near to the limbs. I think there can be little doubt that this explanation of these small terms is correct, and if so, it supplies a satisfactory cause for a number of puzzling inequalities.

The most interesting feature of this result is the general shape of the moon's limb relative to the center of mass and its relation to the principle of isostasy. Here we see with some definiteness that the edge of the southern limb in general is further from the moon's center of mass than the northern. Hence we must conclude that the density at least of the crust of the former is less than that of the latter, in accordance with the principle mentioned. The analogy to the figure of the earth with its marked land and sea hemispheres is perhaps worth pointing out, but the higher ground in the moon is mainly on the south of its Equator, while that on the earth is north.

Unfortunately, we know nothing about the other face of the moon. Nevertheless, it seems worth while to direct the attention of geologists to facts which may ultimately have some cosmogonic applications. The astronomical difficulties are immediate: different corrections for meridian observations in latitude, in longitude, on Mösting A, for occultations and for the photographic method, will be required. I next turn to a question, the chief interest of which is geodetic rather than astronomical. I have mentioned that a certain value of the earth's ellipticity will make the observed motions of the perigee and node agree with their theoretical values. This value is 1/293.7 ± 0.3. Now Helmert's value obtained from gravity determinations is 1/298.3. The conference of Nautical Almanac Directors in 1911 adopted 1/1,297. There is thus a considerable discrepancy. Other evidence, however, can be brought forward.

Not long ago a series of simultaneous observations at the Cape and Greenwich Observatories was made in order to obtain a new value of the moon's parallax. After five years' work a hundred simultaneous pairs were obtained, the discussion of which give evidence of their excellence. Mr. Crommelin, of the Greenwich Observatory, who undertook this discussion, determined the ellipticity of the earth by a comparison between the theoretical and observed values of the parallax. He found an ellipticity 1/294.4 + 1.5 closely agreeing with that which I have obtained. Finally, Col. Clarke's value obtained from geodetic measures was 1/293.5. We have thus three quite different determinations ranging round 1/294 to set against a fourth determination of 1/298. The term in the latitude of the moon which has often been used for this purpose is of little value on account of the coefficient being also dependent on the value of the obliquity of the Ecliptic; such evidence as it presents is rather in favor of the larger value

I omit Hill's value, obtained from gravity determinations, because it is obviously too large. Here, then is a definite issue. To satisfy the observations of the moon in at least three different parts, a value near 1/294 must be used; while the value most carefully found from gravity determinations is 1/298. As far as astronomy is concerned, the moon is the only body for which a correct value of this constant is important, and it would seem inadvisable to use a value which will cause a disagreement between theory and observation in at least three different ways. It is a question whether the conference value should not be changed with the advent of the new lunar tables.

In looking forward to future determinations of this constant, it seems to be quite possible that direct observations of the moon's parallax are likely to furnish at least as accurate a value of the earth's shape as any other method. This can be done, I believe, much better by the Harvard photographic method than by meridian observations. Two identical instruments are advisable for the best results—one placed in the Northern and the other in the Southern Hemisphere, from 60 deg. to 90 deg. apart in latitude, and as nearly as possible on the same meridian. On nights which are fine at both stations, from fifteen to twenty pairs of plates could be obtained. In a few months it is possible that some 400 pairs might be obtained. These should furnish a value for the parallax with a probable error of about 0.02 sec. and a value for the ellipticity within half a unit of the denominator 294.

It would be still more interesting if the two instruments could be set up on meridians in different parts of the earth. The Cape and a Northern observatory—Upsala, for example—would furnish one arc; Harvard and Ariquipa or Santiago another. If it were possible to connect by triangulation Australia with the Asiatic continent, a third could be obtained near the meridian of Brisbane; or, accepting the observed parallax and the earth's ellipticity, we could find by observation the lengths of long arcs on the earth's surface with high accuracy. In any case, I believe that the time must shortly come when the photographic method of finding the moon's place should be taken up more extensively, whether it be used for the determination of the moon's parallax and the earth's ellipticity or not.

The Greenwich meridian observations have been, and continue to be, a wonderful storehouse for long series of observations of the positions of the sun, moon, planets, and stars. In the United States, Harvard Observatory has adopted the plan of securing continuous photographic records of the sky with particular reference to photometric work. Under Prof. Pickering it will also continue the photographic record of the moon's position as long as arrangements can be made to measure the plates and compute the moon's position from them. In spite of the fact that Harvard Observatory has undertaken to continue for the present the work of photographing the moon's position, I believe that this method should find a permanent home in a national observatory. It has already shown itself capable of producing the accuracy which the best modern observations of Greenwich can furnish, and no higher praise need be given. If this home could be found in the Southern Hemisphere, and more particularly in Australia, other advantages would accrue. But we should look for more than this.

In an observatory whose first duty might be the securing of the best daily records of the sky, the positions of the sun, stars, planets, a couple of plates of the moon on every night when she is visible would be a small matter. What is needed is an organization so constructed as to be out of the reach of changing governmental policy, with a permanent appropriation and a staff of the highest character removed from all political influences. It could render immense service to astronomers, not only in the Empire, but all over the world.

I have shown you what the outstanding residuals in the moon's motion are: they consist mainly of long-period fluctuations in the mean longitude. I have not mentioned the secular changes, because the evidence for them does not rest on modern observations, but on ancient eclipses, and these are matters too debatable to discuss in the limited time allotted to me for this address. It may be said, however, that the only secular motion which is capable of being determined from the modern observations, and is not affected by the discussion of ancient eclipses—namely, the secular motion of the perigee—agrees with its theoretical value well within the probable error. With this remark, I pass to the empirical terms.

These unexplained differences between theory and observation may be separated into two parts. First, Newcomb's term of period between 250 and 300 years, and coefficient 13 sec.; and, second, the fluctuations, which appear to have an approximate period of 60 to 70 years. The former appears to be more important than the latter; but from the investigator's point of view it is less so. The force depends on the degree of inclination of the curve to the zero line or on the curvature, according to the hypothesis made. In either case, the shorter-period term is much more striking, and, as I have pointed out on several occasions, it is much more likely to lead to the sources of these terms than the longer period. It is also, at least for the last sixty years, much better determined from observation, and is not likely to be confounded with unknown secular changes. Various hypotheses have been advanced within the last few years to account for these terms. Some of them postulate matter not directly observed, or matter with unknown constants; others, deviations of the Newtonian law from its exact expression; still others, non-gravitational forces. M. St. Blancat examines a variety of cases of intra-Mercurial planets, and arrives at the conclusion that such matter, if it exists, must have a mass comparable

with that of Mercury. Some time ago, I examined the same hypothesis, and arrived at similar results.

The smallest planet with density four times that of water, which would produce the long inequality, must have a disk of nearly 2 sec. in its transit across the sun, and a still larger planet would be necessary to produce the shorter-period terms. But observational attempts, particularly those made by Perrine and Campbell, have always failed to detect any such planet, and Prof. Campbell is of the opinion that a body with so large a disk could hardly have been overlooked. If we fall back on a swarm instead of a single body, we replace one difficulty by two. The light from such a swarm would be greater than that from a single body, and would therefore make detection more likely. If the swarm were more diffused, we encounter the difficulty that it would not be held together by its own attraction, and would therefore soon scatter into a ring. Such a ring cannot give periodic changes of the kind required. The shading of gravitation by interposing matter—e. g., at the time of eclipses—has been examined by Bottlinger. For one reason alone, I believe this is very doubtful. It is difficult to see how new periodicities can be produced. The periods should be combinations of those already present in the moon's motion. The sixty to seventy years' fluctuation stands out in this respect because its period is not anywhere near any period present in the moon's motion, or any probable combination of the moon's periods. Indeed, Dr. Bottlinger's curve shows this: there is no trace of the fluctuation.

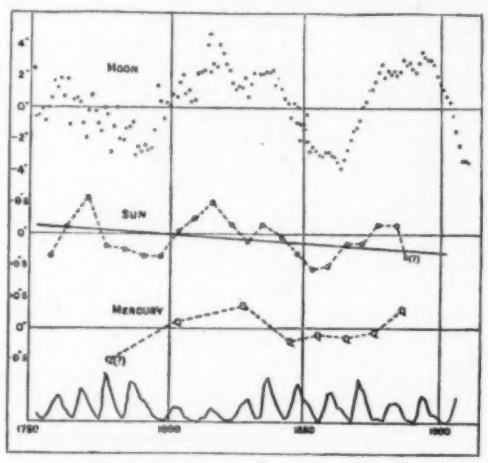
Some four years ago, I examined a number of hypotheses. The motions of the magnetic field of the earth and of postulated fields on the moon had to be rejected, mainly because they caused impossible increases in the mean motion of the perigee. An Equatorial ellipticity of the sun's mass, combined with a rotation period very nearly one month in length, appeared to be the best of these hypotheses. The obvious objections to it are, first, that such an ellipticity, small as it can be (about 1/20,000), is difficult to understand on physical grounds, and, second, that the rotation period of the nucleus which might be supposed to possess this elliptic shape in the sun's Equator is a quantity which is so doubtful that it furnishes no help from observation, although the observed periods are well within the required limits. Dr. Hale's discovery of the magnetic field of the sun is of interest in this connection. Such a field, of non-uniform strength, and rotating with the sun, is mathematically exactly equivalent to an Equatorial ellipticity of the sun's mass, so that the hypothesis might stand from the mathematical point of view, the expression of the symbols in words being alone different.

The last published hypothesis is that of Prof. Turner who assumes that the Leonids have finite mass, and that a big swarm of them periodically disturbs the moon as the orbits of the earth and the swarm intersect. I had examined this myself last summer, but rejected it because, although it explained the straight-line appearance of the curve of fluctuations, one of the most important of the changes of direction in this curve was not accounted for. We have the further difficulty that continual encounters with the earth will spread the swarm along its orbit, so that the swarm with this idea should be a late arrival, and its periodic effect on the moon's motion of diminishing amplitude. With respect to the latter, the observed amplitude seems rather to have increased.

The main objection to all these ideas consists in the fact that they stand alone: there is as yet little or no collateral evidence from other sources. The difficulty, in fact, is not that of finding a hypothesis to fit the facts, but of selecting one out of many. The last hypothesis which I shall mention is one which is less definite than the others, but which does appear to have some evidence in its favor. The magnetic forces mentioned above were changes in the directions of assumed magnetic fields. If we assume changes in the intensities of the fields themselves, we avoid the difficulties of altering portions of the moon's motion other than that of the mean motion. We know that the earth's magnetic field varies, and that the sun has such a field, and there is no inherent improbability in attributing similar fields to the moon and the planets. If we assume that variations in the strength of these fields arise in the sun and are communicated to the other bodies of the Solar System, we should expect fluctuations having the same period and of the same or opposite phase, but differing in magnitude.

It therefore becomes of interest to search for fluctuations in the motions of the planets similar to that found in the moon's orbit. The material in available form for this purpose is rather scanty; it needs to be a long series of observations reduced on a uniform plan. The best I know is in Newcomb's "Astronomical Constants." He gives there the material for the earth arranged in groups of a few years at a time. The results for Mercury, given for another purpose, can also be extracted from the same place. For Venus and Mars, Newcomb unfortunately only printed the normal equations, from which he deduces the constants of the orbit. On the screen is shown a slide (see map) which exhibits the results for the Earth and Mercury compared with those for the moon. In the uppermost curve are reproduced the minor fluctuations of the moon shown earlier; the second curve contains those of the earth's longitude; the third, those of Mercury's longitude. [By accident, the mean motion correction has been left in the earth curve; the zero line is therefore inclined instead of being horizontal.] It will be noticed that the scales are different, and that the earth curve is reversed. In spite of the fact that the probable errors of the results in the second and third curves are not much less than their divergences from a straight line, I think that the correlation exhibited is of some significance. If it is, we have here a force whose period, if period in the strict sense it has, is the same as that of the effect. The latter is not, then, a resonance from combination with another period. We must, therefore, look for some kind of a surge spreading through the Solar System, and affecting planets and satellites the same way, but to different degrees. The lowest curve is an old friend—that of Wolf's sunspot-frequency—put there, not for that reason, but because the known connection for the last sixty years between sunspot-frequency and prevalence of magnetic disturbance enables us with fair probability to extend the latter back to 1750. With some change of phase, the periods of high and low maxima correspond nearly with the fluctuations above.

The eleven-year oscillation is naturally eliminated from the group results for the Earth and Mercury. One might expect it to be present in the lunar curve; but, owing to its shorter period, we should probably not obtain a coefficient of over half a second. Notwithstanding this fact, it is a valid objection to the hypothesis that there is no evidence of it in the moon's motion. Reasons may exist for this; but until the mechanism of the action can be made more definite, it is hardly worth while to belabor



the point. The hypothesis presents many difficulties. Even if one is disposed to admit provisionally a correlation between the four curves—and this is open to considerable doubt—it is difficult to understand how, under the electron theory of magnetic storms, the motions of moon and planets can be sensibly affected.

I am perhaps catching at straws in attempting to relate two such different phenomena with one another; but when we are in the presence of anomalies which show points of resemblance, and which lack the property of analysis into strict periodic sequences, some latitude may be permissible.

In conclusion, what, it may well be asked, is the future of the lunar theory now that the gravitational effects appear to have been considered in such detail that further numerical work in the theory is not likely to advance our knowledge very materially? What good purpose is to be served by continuous observation of the moon and comparison with the theory? I believe that the answer lies mainly in the investigation of the fluctuations already mentioned. I have not referred to other periodic terms which have been found, because the observational evidence for their real existence rests on foundations much less secure. These need to be examined more carefully, and this examination must, I think, depend mainly on future observations rather than on the records of the past. Only by the greatest care in making the observations, and in eliminating systematic and other errors from them, can these matters be fully elucidated. If this can be achieved, and if the new theory and tables serve, as they should, to eliminate all the known effects of gravitation, we shall be in a position to investigate with some confidence the other forces which seem to be at work in the Solar System, and at which we can now only guess.

Assistance should be afforded by observations of the sun and planets, but the moon is nearest to us and is, chiefly on that account, the best instrument for their detection. Doubtless other investigations will arise in the future. But the solution of the known problems is still to be sought, and the laying of the coping-stone on the edifice reared through the last two centuries cannot be a simple matter.

The Sale of Mineral Waters in the United States

In a report issued by the United States Geological Survey some interesting facts are given in relation to the production of mineral waters in the United States, from which it appears that the sale of such waters reached the maximum of 64,674,486 gallons in 1909, since which time the reports show the business had decreased in 1913 to 57,867,000 gallons, in spite of the fact that the field of the statistics has been extended and reports have been received from an increasing number of operators. Not only has this change taken place, but there is also a tendency toward a lower price, which may be attributed to decreased sales of high-priced waters and increased sales of low-priced waters. The general tendency toward a decline in price is doubtless due to demand for good pure potable bottled waters at moderate cost in place of the former demand for waters reputed to possess exceptional curative properties. Detailed examination of the statistics for the last few years shows that the installation of municipal purification plants in several large cities has been followed by marked decrease in the sales of spring waters in the immediate vicinity, and doubtless general improvements in the quality of public water supplies in smaller municipalities throughout the country has similarly affected the mineral-water business and has contributed to the present lowered production.

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